PHOTOMETRICS 3000

USER'S MANUAL

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PHOTOMETRICS LTD.
TUCSON, ARIZONA

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TABLE OF CONTENTS

Warranty

Table of Contents i

Figures and Tables ii

1.0 Precautions 1

2.0 Hookup and Checkout Procedures 2

- 2.1 Filling the CH210 Camera Head Cryostat 2
- 2.2 Hookup 6
- 2.3 Startup 11
- 2.4 Checkout and Shutdown 14

3.0 Customizations 18

4.0 Photometrics 3000 Hardware 19

- 4.1 System Overview 19
- 4.2 Photometrics 3000 Computer 27
- 4.3 CE200 Camera Electronics Unit 31
- 4.4 CH210 Camera Head Cryostat 37
- 4.5 CH220 Camera Head 42
- 4.6 CH230 Camera Head 45
- 4.7 IC200 Integrated Camera Head and Electronics Unit 48

5.0 Noise 55

6.0 Troubleshooting Procedures/Card Layouts 59

Index 68

FIGURES AND TABLES

2.0 Hookup and Checkout Procedures

Figure 2-1 Neck Extension Tube, and Neck Extension Tube Insertion and Removal Tool 4
Figure 2-2 Cryostat Fill Tube Arrangement 5
Figure 2-3 Photometrics 3000 System Cables: Option 1 7
Figure 2-4 Photometrics 3000 System Cables: Option 2 8
Figure 2-5 Photometrics 3000 Connectors 10
Figure 2-6 How to Access CCD Commands 12
Table 2-1 Photometrics 3000 System Cables 11
Table 2-2 Supported Terminals 14

4.0 Photometrics 3000 Hardware

Figure 4-1 Photometrics 3000 System: Options 1 and 2 20
Figure 4-2 Photometrics 3000 Computer 21
Figure 4-3 System Functions 22
Figure 4-4 CE200 Camera Electronics Unit 24
Figure 4-5 CCD Camera Head 25
Figure 4-6 Computer Card Cage Layout 29
Figure 4-7 CE200 Mechanical Specifications 32
Figure 4-8 Bottom-Viewing CH210 Cryostat Mechanical Specifications 38
Figure 4-9 CH220 Camera Head Mechanical Specifications 43
Figure 4-10 CH230 Camera Head Mechanical Specifications 46
Figure 4-11 IC200 Mechanical Specifications 49
Figure 4-12 IC200 Integrated Camera Head 50
Figure 4-13 IC200 Top View, Showing Card Cage 52
Table 4-1 CE200 Temperature Setpoint and Control Dial Settings 36

1.0 PRECAUTIONS

1.1 General Precautions

The following precautions must be taken to prevent damage to your Photometrics 3000 system.

- All components must be at room temperature before the system is turned on.
- Never connect or disconnect any cable while the system is turned on. An unconnected cable segment can become electrically charged and, if reconnected, can damage the CCD.
- Always install the shorting plug on the camera head when the camera head is disconnected from its cable.
- The system has been configured at the factory for 110V, 50/60 Hz; 220V, 50/60 Hz; or 240 V, 50/60 Hz. At least 1 kVA capacity is required.
- Never impede airflow through equipment by obstructing chassis vents.

1.2 Precautions for the CH210 Camera Head Cryostat

- Always wear gloves and goggles or a full face shield when handling liquid nitrogen for the CH210 camera head cryostat.
- Before transporting the CH210 camera head cryostat, the support rod must be installed in the neck of the cryostat. **The cryostat flask must be at room temperature prior to installation of the support rod.** If the flask is cold when the support rod is installed, the warming of any liquid nitrogen remaining in the flask causes the internal pressure in the cryostat to rise as in a pressure cooker. This creates a very dangerous situation that can lead to personal injury.
- The bottom-looking CH210 camera head cryostat is intended for use in either an upright or an inverted position. If a cryostat is filled with liquid nitrogen, and then turned on its side, one-half liter of liquid nitrogen will spill out. A small amount of liquid nitrogen also is expected to spill out when a filled cryostat is inverted 180° after installation of the extension tube.
- Never open the vacuum valve on the CH210 camera head cryostat unless the cryostat is at room temperature.

2.0 HOOKUP AND CHECKOUT PROCEDURES

2.1 FILLING THE CH210 CAMERA HEAD CRYOSTAT

Section 2.1 is pertinent only to systems provided with the CH210 camera head cryostat. Users of systems provided with either the CH220 or CH230 camera head or with the IC200 integrated camera head and electronics unit should proceed to Section 2.2.

2.1.1 Required Equipment Not Supplied with the CH210 Camera Head Cryostat

The following equipment is required but not supplied with your CH210 camera head cryostat:

- Storage dewar filled with liquid nitrogen. A 25-liter dewar with a pressurized valving system is recommended.
- Tubing to transfer liquid nitrogen from the storage dewar to the cryostat. Do not use polyvinyl chloride or soft plastic tubing, as such tubing can shatter and cause personal injury. Nylon,Teflon™, and polyethylene are all acceptable materials. A length of less than four feet is recommended. The diameter of the tubing is determined by the diameter of the storage dewar outlet to which it is to be attached. The tubing must fit tightly over the storage dewar outlet.
- Two hose clamps and a 3- to 4-inch length of rubber tubing to attach the transfer tubing to the fill tube's fill port. The fill port has an outer diameter of 0.5 inch.
- Gloves and goggles or full face mask for personal safety.

2.1.2 Precautions to be Taken in the Use of Liquid Nitrogen

2.1.2.1 Liquid nitrogen is not dangerous if carefully used. It can be extremely hazardous if certain simple precautions are not taken and correct procedures are not used.

2.1.2.2 Do not allow bystanders into the area while transferring liquid nitrogen.

2.1.2.3 The temperature of liquid nitrogen is 77° K and can cause severe frostbite if brought in contact with the skin. Gloves and protective clothing, particularly goggles, should be worn when doing any operation involving liquid nitrogen. The eyes are especially vulnerable; permanant cornea damage results if liquid nitrogen is splashed into the eyes.

2.1.2.4 Always ensure that hoses carrying liquid nitrogen are securely clamped and that excessive feed pressures are not used which could lead to a ruptured hose or the failure of a hose connection. Usually only one person is needed to fill the CH210 camera head cryostat.

2.1.3 Neck Extension Tube and CH210 Camera Head Cryostat Capacity

2.1.3.1 A specially designed neck extension tube is provided for cryostats that are to be used in an inverted orientation. The cryostat can be filled with liquid nitrogen with or without the neck extension tube in place. However, the presence or absence of the neck extension tube determines the orientation in which that cryostat can be filled or used (see Section 2.1.4). As a rule, the neck extension tube should be used whenever the fill end of the cryostat is below the level of the end plate.

2.1.3.2 A cryostat that is filled in an upright or inverted position has a capacity of one liter. If the cryostat is turned on its side, half of the liquid nitrogen will spill out, leaving one-half liter of liquid nitrogen in the cryostat.

2.1.3.3 If filled on its side with or without the neck extension tube in place, the cryostat's capacity is one-half liter.

2.1.3.4 The cryostat cannot be filled in an upright position with neck extension tube in place.

2.1.4 Filling the CH210 Camera Head Cryostat

2.1.4.1 Remove the support rod from the neck of the cryostat by unscrewing the knurled lock ring holding the rod in place. Always install the support rod when transporting the cryostat (see Section 1.0, Precautions).

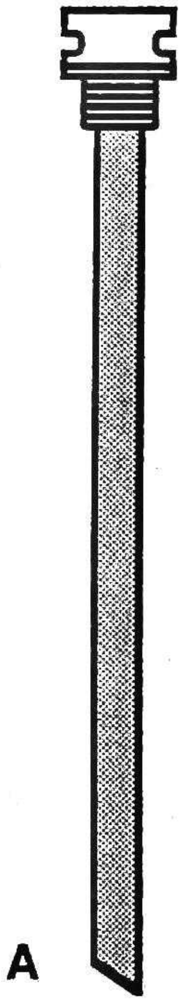
2.1.4.2 When filling the cryostat for inverted use, screw the extension tube into place with the insertion tool provided with your system (figure 2-1).

2.1.4.3 Clamp one end of the rubber tubing to the transfer tubing with a hose clamp (figure 2-2).

2.1.4.4 Clamp the other end of the rubber tubing to the fill tube's fill port with a second hose clamp.

2.1.4.5 Fit the free end of the transfer tubing tightly over the storage dewar outlet.

2.1.4.6 Position the fill tube in the neck of the cryostat and hand tighten the knurled lock ring.



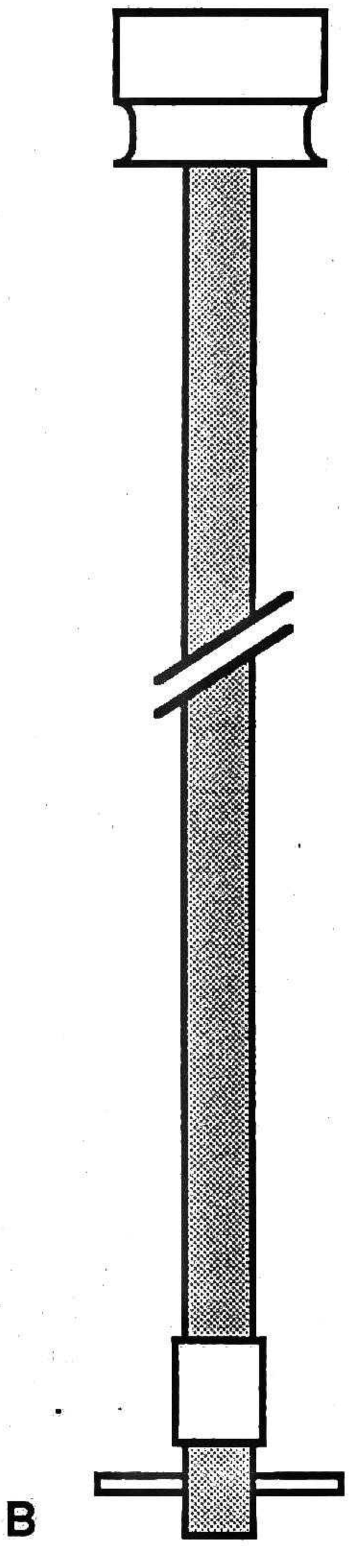


Figure 2-1A. Neck Extension Tube

Figure 2-1B. Neck Extension Tube Insertion and Removal Tool

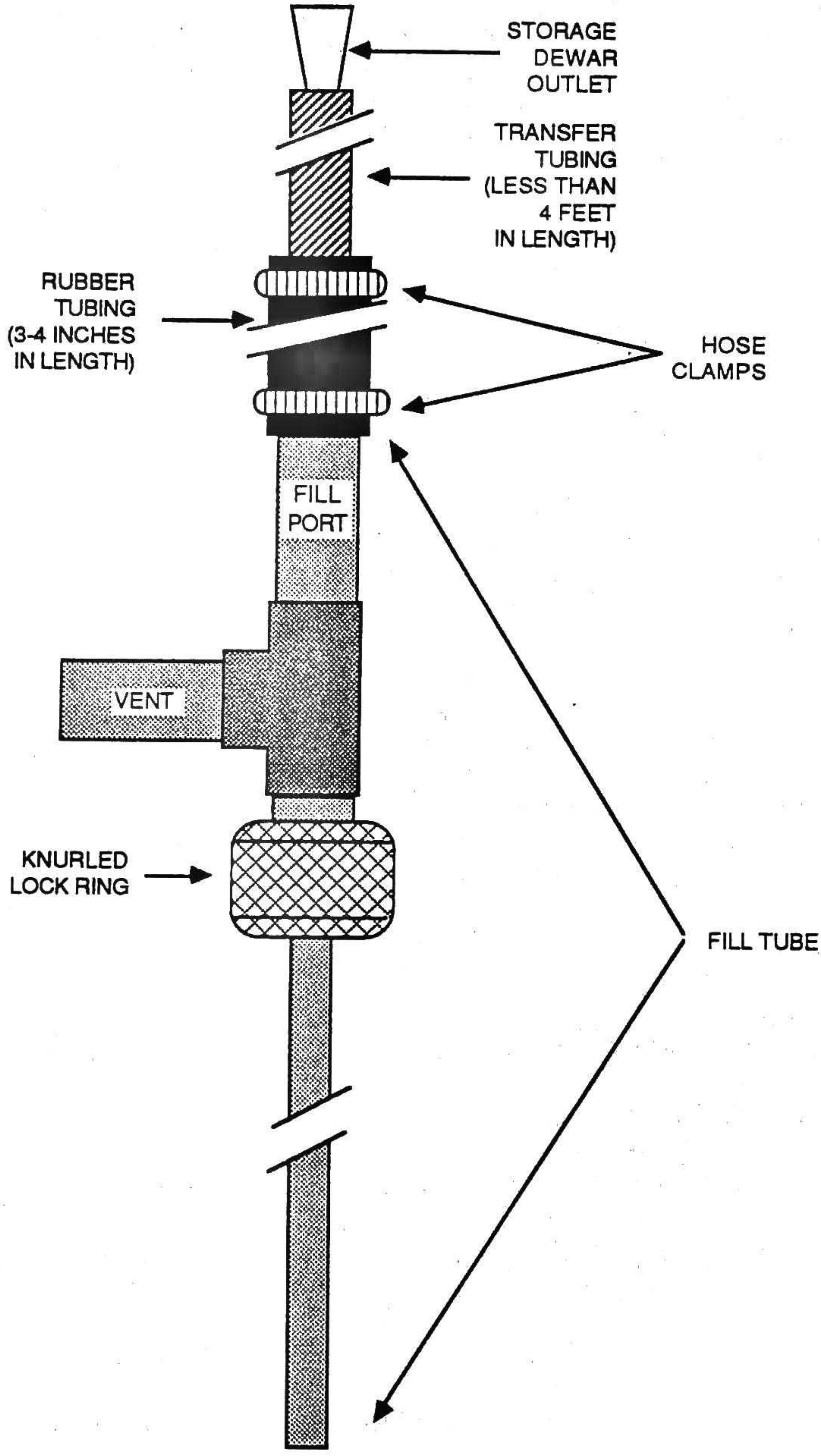

STORAGE DEWAR OUTLET
TRANSFER TUBING (LESS THAN 4 FEET IN LENGTH)
RUBBER TUBING (3-4 INCHES IN LENGTH)
HOSE CLAMPS
FILL PORT
VENT
KNURLED LOCK RING
FILL TUBE

Figure 2-2. Cryostat Fill Tube Arrangement

2.1.4.7 Mount crystat in its normal inverted position before filling. With rubber gloves and goggles or a face mask on, open the pressurized valve on the storage dewar to fill the cryostat. At first, all of the transferred liquid nitrogen turns to gas and is expelled out the fill tube vent. When the cryostat cools to the temperature of the liquid nitrogen, the actual transfer of liquid begins. (The action of the liquid nitrogen coming in contact with the warm flask is much like that of water poured into a pan sitting on a hot stove.) When the cryostat reaches the temperature of the liquid nitrogen, a momentary increase in the venting gas often occurs. This is normal and is not a dangerous condition. The cryostat has filled when liquid nitrogen begins to spurt out the fill tube vent.

2.1.4.8 Close the pressurized valve on the storage dewar.

2.1.4.9 Unscrew the knurled lock ring and withdraw the fill tube from the cryostat if you choose not to top off the cryostat according to paragraph 2.1.4.13.

2.1.4.10 If the cryostat is to be used in an upright orientation, the same procedure can be followed above but without using the neck extension tube and with cryostat in upright position during filling process.

2.1.4.11 Should it be required to fill the cryostat in an upright position before using it in an inverted orientation, it is possible to install the neck extension tube only after filling is complete. Precautions should be taken (safety goggles & gloves) when installing neck extension tube as liquid nitrogen will boil up and spill out of the neck of the cryostat. It should be screwed down quickly with neck insertion tool and the cryostat should be inverted immediately after withdrawal of the tool. The liquid nitrogen will stop spilling out as soon as the cryostat is inverted. It helps to cool down the neck extension tube before insertion, in a flask of liquid nitrogen, using the insertion tool as a handle. Once inverted, the fill tube may be installed for topping off the cryostat according to paragraph 2.1.4.13.

2.1.4.12 Wait forty minutes to an hour for complete cooldown of the cryostat.

2.1.4.13 For maximum hold time, the cryostat can be topped off with additional liquid nitrogen after the boiling has diminshed to a low level. Unscrew the knurled lock ring and withdraw the fill tube from the cryostat. The cryostat is ready for use.

2.2 HOOKUP

2.2.1 The standard ***Option 1 Photometrics 3000 computer system*** includes one Photometrics 3000 computer, one CE200 camera electronics unit, and one CH210, CH220, or CH230 camera head (figure 2-3).

2.2.2 The standard ***Option 2 Photometrics 3000 computer system*** includes one Photometrics 3000 computer and one IC200 integrated camera head/camera electronics unit (figure 2-4).

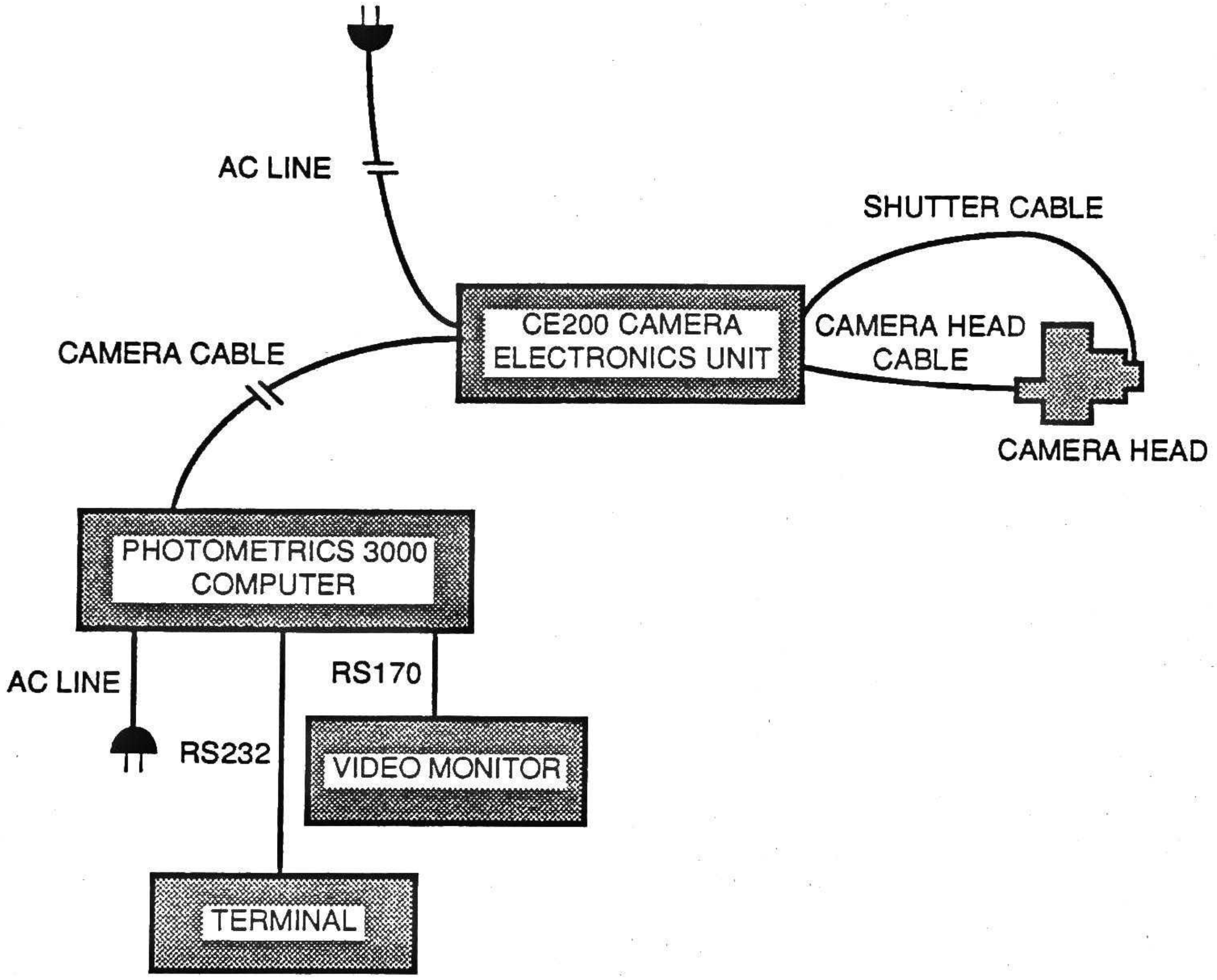


Figure 2-3. Photometrics 3000 System Cables: Option 1

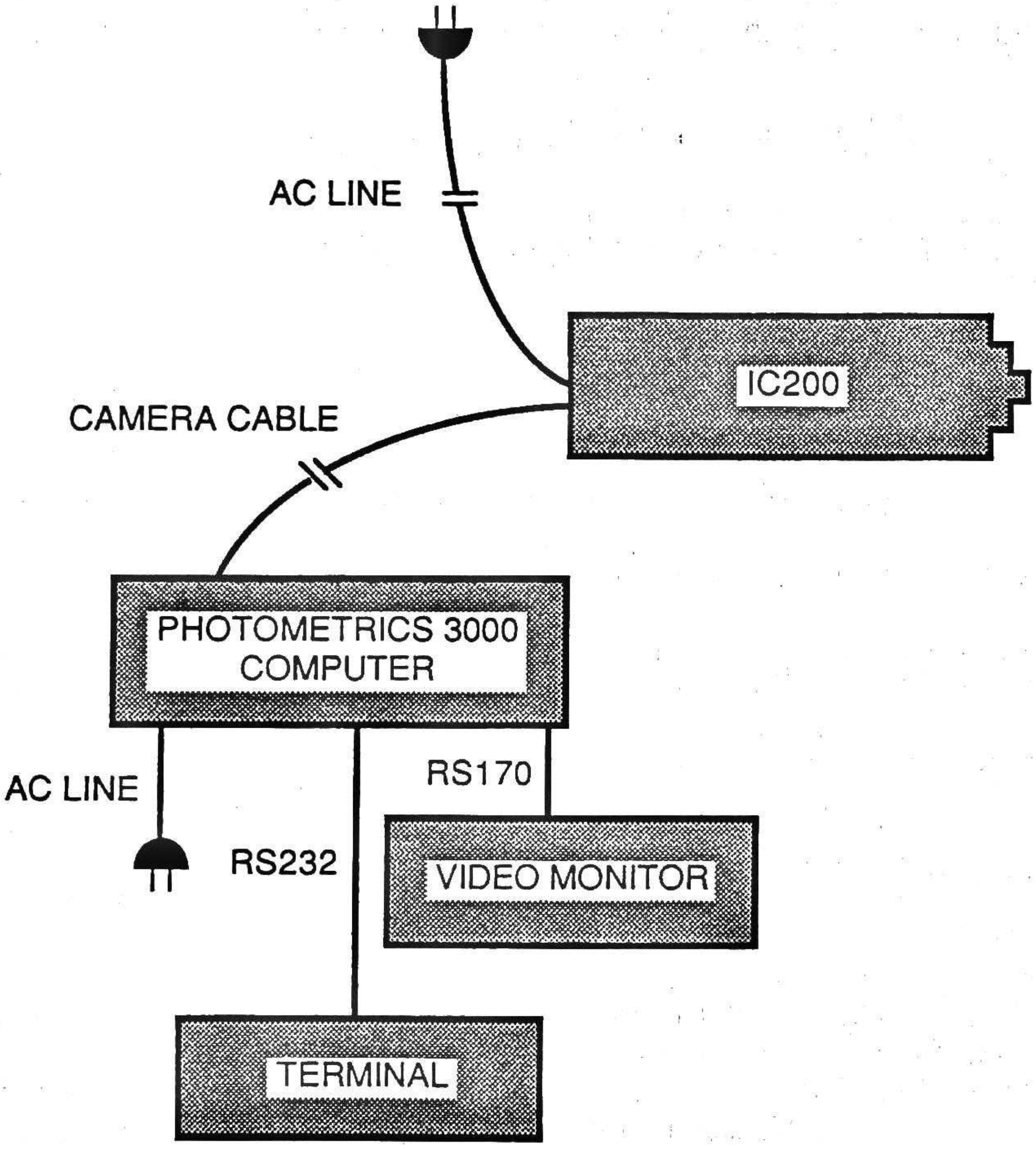


Figure 2-4. Photometrics 3000 System Cables: Option 2

2.2.3 Table 2-1 is a guide for the connection of system cables.

2.2.4 Unpack the system in a location with enough space to neatly arrange cables and system components.

2.2.5 Compare the unpacked components and cables to those listed in the system packing list and examine them for shipping damage. If damage is found, contact Photometrics Ltd. at 602/623-8961.

2.2.6 The power is turned off for paragraphs 2.2.7 through 2.2.17.

2.2.7 Use the RS232 cable labeled CONSOLE on one end to connect computer port CONSOLE to the appropriate terminal port. See figure 2-5 for computer connectors.

2.2.8 Use the coaxial cable with BNC connectors to link RS170 video monitor port VIDEO IN to computer jack V1. Set the switch on the back of the monitor for 75 ohm termination.

2.2.9 Use the adaptor provided to connect the mouse to computer port S1.

2.2.10 Connect AC power cables to the monitor, terminal, and CE200/IC200.

2.2.11 Use the camera cable to connect computer port P2 to CE200/IC200 port CAMERA CABLE.

2.2.12 Connect the captive cable attached to the camera shutter to the telephone jack on the CE200/IC200 frontplate.

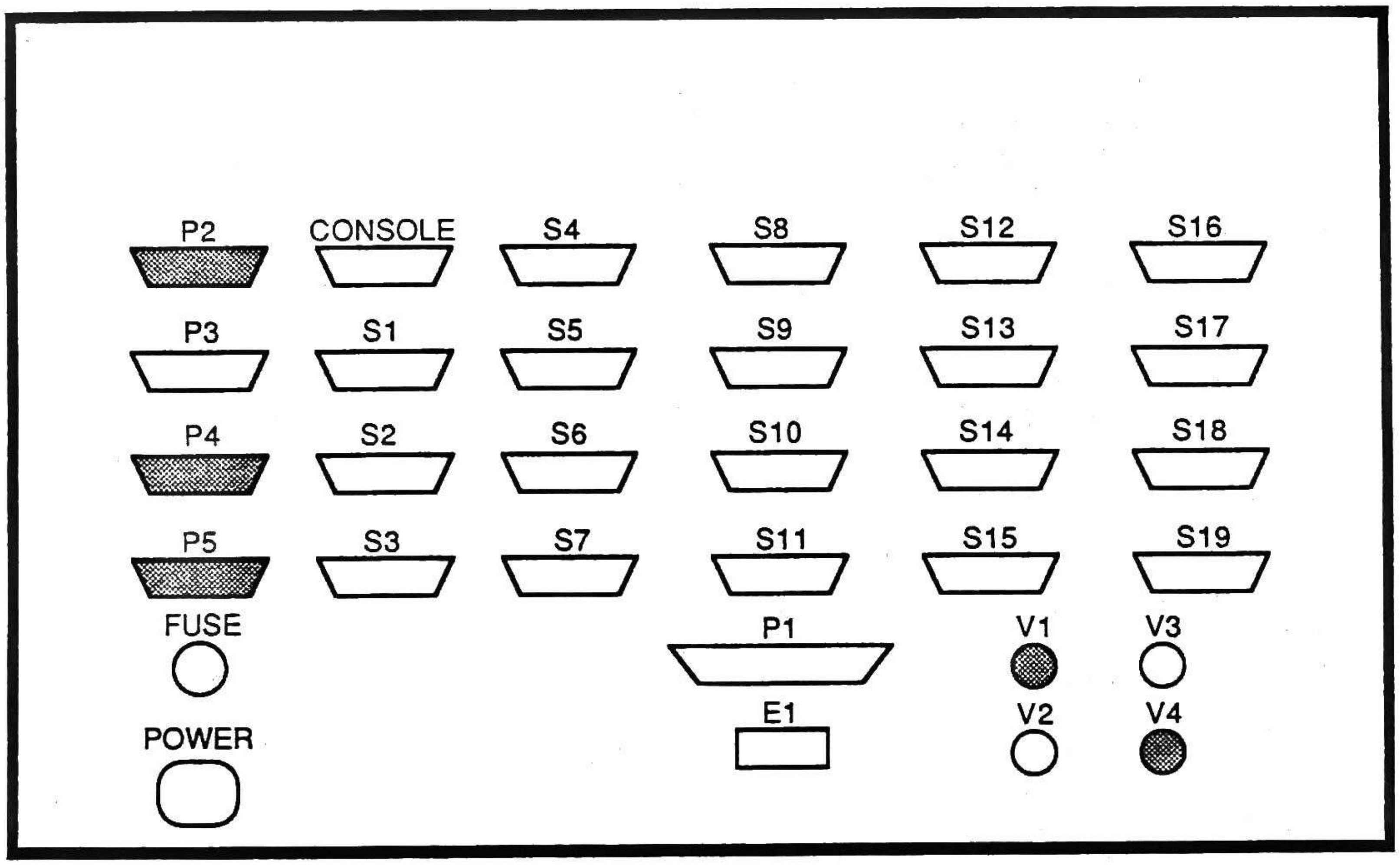
2.2.13 *Users of systems with a CE200, continue to paragraph 2.2.14. Users of systems with an IC200, go to paragraph 2.2.17.*

2.2.14 Twist and remove the shorting plug from the camera head and connect the captive cable from the CE200. Use care, as the pins on the camera connector are mounted in a hermetic glass connector and are easily damaged. An extension cable should not be used between the CE200 and the camera head. If a longer cable is needed, contact Photometrics Ltd.

2.2.15 Attach the Pentax lens to the camera head. The lens has a standard bayonet connection. Align the red dot on the lens with the dot on the lens mount. Turn the lens clockwise until it seats in the lens mount.

2.2.16 **Option 1 Systems with CH220 camera head only:** Use 1/4-inch inner diameter hosing to connect the CH220 camera head hose fittings to a coolant source. The recommended minimum flow rate is 0.15 gallons per minute; the recommended coolant is 10% ethylene glycol in deionized water.

2.2.17 Ensure that all connections are secure and that all screwlocks are in place.



P2 = CAMERA

P4 = SCSI BUS

P5 = SCSI TERMINATOR

V1 = VIDEO
V4 = EXTERNAL TRIGGER

Figure 2-5. Photometrics 3000 Connectors

2.2.18 When all electronic components are at ambient temperature, flip the switches on the terminal, monitor, CE200/IC200, and computer. Within five seconds, the Winchester disk should spin up and emit a tone. A cursor appears on the terminal screen.

2.2.19 There are four lights on the backplate of the CE200/IC200. The AC and DC lights should be lit to indicate that AC and DC power is present. A relay interlock prevents DC power from being delivered to the CE200/IC200 from the computer if AC power is switched off. The red HEATING and green COOLING lights indicate the status of the CCD temperature regulation circuit. The relative brightness of these two lights varies as ambient temperature changes. When the COOLING light is brightly lit, maximum cooling is indicated. As the operating temperature is reached, the COOLING light dims and the HEATING light may come on.

TABLE 2-1. PHOTOMETRICS 3000 SYSTEM CABLES

FROM	TO	COMMENTS
P4 HSE		SCSI Port
P2 HSE	Camera Head	Camera Control
Console HSE	Terminal	Serial Port B
S1 HSE	Printer Port	Serial Port A
S2 HSE	Mouse Input	Serial Port D
S3 HSE	User-definable	Serial Port C
V1 HSE		RS170 Video Output
V4 HSE		External Trigger

2.3 STARTUP

2.3.1 The Photometrics 3000 UNIX™ and FORTH user's manuals discuss system startup in detail. An abbreviated version is presented here.

2.3.2 In this manual, user entries and computer responses are in bold print (**command**). In UNIX™, each command entry must terminate with a carriage return (**<cr>**); each FORTH command line must terminate with a carriage return.

2.3.3 Figure 2-6 shows the entries necessary to boot the Photometrics 3000 system from the Winchester disk.

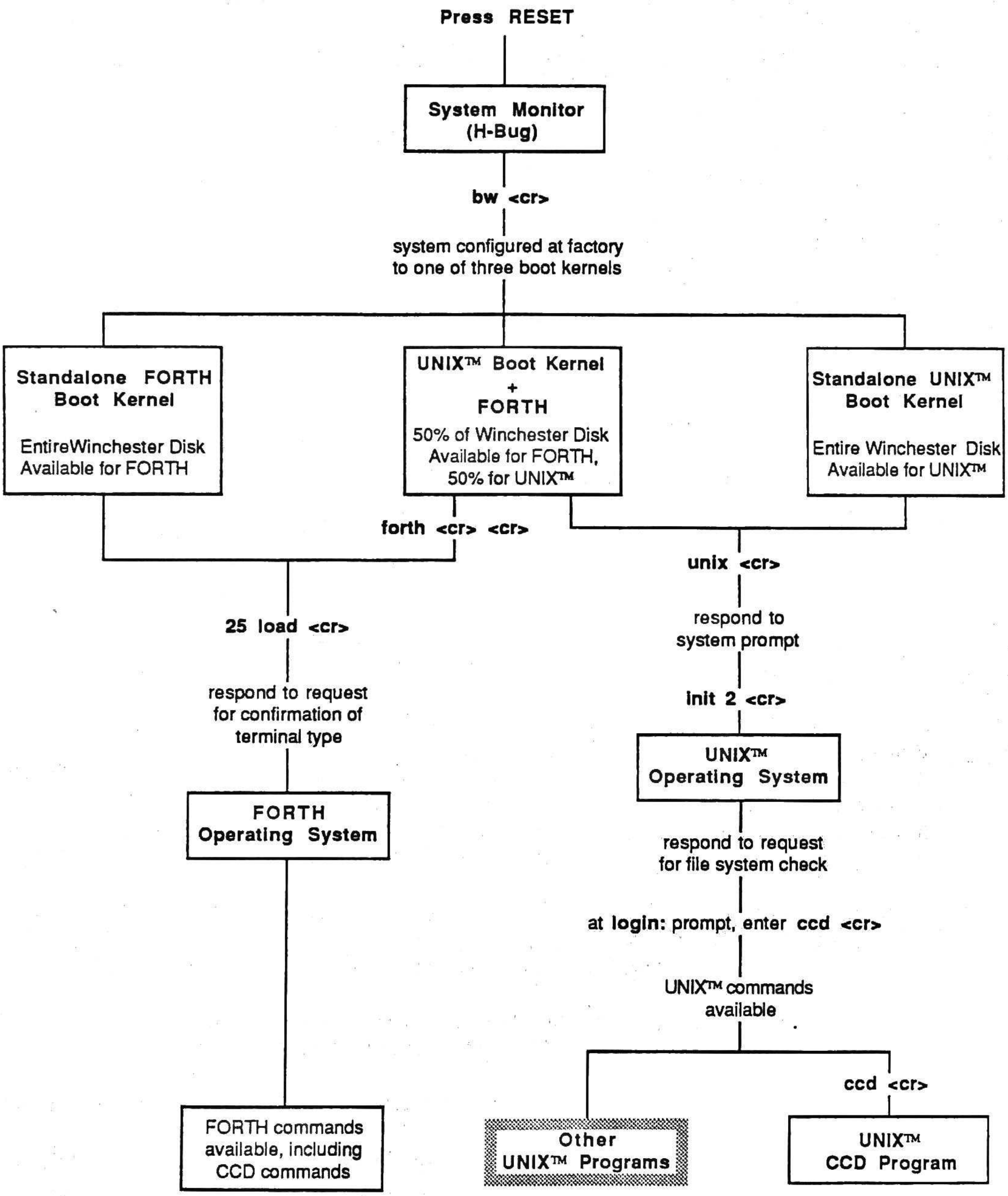

Press RESET
System Monitor (H-Bug)
bw <cr>
system configured at factory to one of three boot kernels
Standalone FORTH Boot Kernel
EntireWinchester Disk Available for FORTH
UNIX™ Boot Kernel + FORTH
50% of Winchester Disk Available for FORTH, 50% for UNIX™
Standalone UNIX™ Boot Kernel
Entire Winchester Disk Available for UNIX™
forth <cr> <cr>
unix <cr>
25 load <cr>
respond to request for confirmation of terminal type
FORTH Operating System
FORTH commands available, including CCD commands
respond to system prompt
init 2 <cr>
UNIX™ Operating System
respond to request for file system check
at login: prompt, enter ccd <cr>
UNIX™ commands available
ccd <cr>
Other UNIX™ Programs
UNIX™ CCD Program

Figure 2-6. How to access CCD commands for systems configured with the Standalone FORTH Boot Kernel, the UNIX™Boot Kernel with FORTH, or the UNIX™ Boot Kernel.

2.3.4 Press the **RESET** button on the computer. The terminal screen displays the following message:

```
Heurikon Corporation
M10-Bug
Ver 1.X
```

where **X** represents the version number of your Heurikon H-Bug Monitor program.

2.3.5 A system prompt (>) appears.

2.3.6 **bw** boots the computer from the Winchester disk.

2.3.7 The next event varies with the software shipped with your system.

2.3.8 Booting the Standalone UNIX™ Boot Kernel

2.3.8.1 The following message appears on the terminal screen:

```
Standalone Boot

       :
```

2.3.8.2 **unix <cr> <cr>** produces lines of text that culminate in the root prompt (#). When this prompt appears, enter **init 2.**

2.3.8.3 The computer asks if the file systems are to be checked. If the system is being brought up after a crash or other unusual activity, enter **y**; otherwise, enter **n**. The file check takes approximately three minutes. A normal execution produces five check lists; an abnormal execution produces some extra lines and may solicit user permission for some corrective action. The Heurikon UNIX System V User's Manual discusses file checks.

2.3.8.4 When **login**: appears on the screen, enter **ccd.** If anything other than **ccd** is entered, the system requests a password. Enter a carriage return to skip over the password. The system again prompts for a login.

2.3.8.5 When the % prompt appears, **ccd** initiates the CCD camera control program. The program prompt is an asterisk (*).

2.3.9 Booting the UNIX™ Boot Kernel Plus FORTH

2.3.9.1 The following message appears on the terminal screen:

```
Standalone Boot

       :
```

2.3.9.2 Enter **forth <cr> <cr>.**

2.3.9.3 The Io, Inc. banner appears, followed by the FORTH operating system prompt (\).

2.3.9.4 **25 load** enters the FORTH operating system. After a display of redefinition messages, the computer requests a confirmation of terminal type. If the terminal listed is correct, enter a carriage return. To change the terminal type, refer to table 2-2 for a listing of supported terminals and enter the corrected terminal code.

2.3.9.5 When the FORTH operating system prompt reappears, the computer is ready to run FORTH commands.

TABLE 2-2. SUPPORTED TERMINALS

TERMINAL CODE	MANUFACTURER	COMMENTS
vt100	(generic)	Non-graphics
hr100	Selanar	Emulates VT100
tvi925*	TeleVideo	Non-graphics
mt301	MicroTerm	Emulates VT100
qvt220	Qume	Emulates VT100

* Adam3a emulates TVI925. Use tvi925 terminal code for Adam3a terminal.

2.3.10 Booting the Standalone FORTH Boot Kernel

2.3.10.1 The Io, Inc. banner appears, followed by the FORTH operating system prompt (\).

2.3.10.2 **25 load** enters the FORTH operating system. After a display of redefinition messages, the computer requests confirmation of the terminal type in use. If the terminal listed is correct, enter a carriage return. To change the terminal type, refer to table 2-2 for a listing of supported terminals and enter the corrected terminal code.

2.3.10.3 When the FORTH operating system prompt reappears, the computer is ready to run FORTH commands.

2.4 CHECKOUT AND SHUTDOWN

2.4.1 Photometrics 3000 UNIX™ Software

2.4.1.1 The Photometrics 3000 UNIX™ User's Manual provides a comprehensive tutorial of the software.

2.4.1.2 User entries and system responses are in bold print (**command**). Each command entry must terminate with a carriage return (**<cr>**).

2.4.1.3 In this system checkout, users acquire an image, subtract DC offset from that image, and acquire a listing of images currently stored in RAM.

2.4.1.4 **cisc** continuously clears the CCD of residual charge and dark current while the CCD cools down to its optimal operating temperature. Although the system may be used immediately after power up, it is recommended that the CCD be allowed to cool for approximately ten minutes. Optimal heating temperatures have been reached when the COOLING and HEATING lights on the CE200/IC200 dim or are extinguished.

2.4.1.5 Point the camera at an object or scene, set the focal length, and close the aperture to f/16 or f/22. Because some CCDs are very light sensitive, do not expose a brightly lit object or scene. If a bright subject cannot be avoided, standard neutral density lens filters may help to prevent CCD saturation. Bright light does not harm the CCD.

2.4.1.6 **focus 10 2** reads out ten 100 x 100 pixel images that have been exposed for two-tenths of a second each. Manually adjust the aperture and focal length while you view the results of your adjustments on the video display.

2.4.1.7 **obs 2 <cr> qshow** acquires and displays the focused image.

2.4.1.8 **ci 2 <cr> bias** takes a 0-second exposure that clears the CCD of residual charge and measures the DC offset.

2.4.1.9 **ci 1 <cr> i- 2 <cr> qshow** subtracts the DC offset from the image that you acquired in paragraph 2.4.1.7, then displays the bias-subtracted image.

2.4.1.10 **qimages** lists all existing RAM image caches and the dimensions of each.

2.4.1.11 **quit** exits the CCD program. When the CCD user prompt, %, appears, other valid UNIX™ multiuser commands can be accepted. If a tape device has been opened for use, it is closed automatically.

2.4.1.12 As a precaution, revert to single user mode. This step is recommended, but it is not essential prior to powering down the system. Set yourself up as the superuser by

```
sync
sync
su
```

After the # prompt appears, indicating that you are now the superuser, **init s** returns the system to single user mode. A message appears when **syscon** is linked to the console. After twenty seconds, another set of lines indicates single user mode.

2.4.1.13 Enter

```
sync
sync
```

when the # prompt reappears.

2.4.1.14 Press the **RESET** button, switch off the CE200/IC200, then switch off the remaining hardware.

2.4.2 Photometrics 3000 FORTH Software

2.4.2.1 The Photometrics 3000 FORTH User's Manual provides a comprehensive tutorial of the software.

2.4.2.2 User entries and system responses are in bold print (**command**). Each line of commands must terminate with a carriage return (**<cr>**).

2.4.2.3 In this system checkout, users acquire an image, subtract DC offset from that image, and acquire a listing of images currently stored in RAM.

2.4.2.4 **cisc** continuously clears the CCD of residual charge and dark current while the CCD cools down to its optimal operating temperature. Although the system may be used immediately after power up, it is recommended that the CCD be allowed to cool for approximately ten minutes. Optimal heating temperatures have been reached when the COOLING and HEATING lights on the CE200/IC200 dim or are extinguished.

2.4.2.5 Point the camera at an object or scene, set the focal length, and close the aperture to f/16 or f/22. Because some CCDs are very light sensitive, do not expose a brightly lit object or scene. If a bright subject cannot be avoided, standard neutral density lens filters may help to prevent CCD saturation. Bright light does not harm the CCD.

2.4.2.6 **10 2 focus** reads out ten 100 x 100 pixel images that have been exposed for two-tenths of a second each. Manually adjust the aperture and focal length while you view the results of your adjustments on the video display.

2.4.2.7 **2 obs qshow** acquires and displays the focused image.

2.4.2.8 **2 ci bias** takes a 0-second exposure that clears the CCD of residual charge and measures the DC offset.

2.4.2.9 **1 ci 2 i- qshow** subtracts the DC offset from the image that you acquired in paragraph 2.4.2.7, then displays the bias-subtracted image.

2.4.2.10 **qimages** lists all existing RAM image caches and the dimensions of each.

2.4.2.11 To end a session, switch off the CE200/IC200, then switch off the remaining hardware.

3.0 CUSTOMIZATIONS

This manual is provided as part of a standard Photometrics 3000 system package. No customizations have been made to this system.

4.0 PHOTOMETRICS 3000 HARDWARE

4.1 SYSTEM OVERVIEW

4.1.1 INTRODUCTION

The Photometrics 3000 computer system has two primary configurations. The first has a CH210, CH220, or CH230 CCD camera head connected by cable to a CE200 camera electronics unit and Photometrics 3000 computer. In the second configuration, an IC200 integrated camera head and electronics unit is connected by cable to a Photometrics 3000 computer. Figure 4-1 provides an overview of the two configurations. Figures 4-2 and 4-3 are block diagrams of the Photometrics 3000 computer and of system functions, respectively.

4.1.2 PHOTOMETRICS 3000 COMPUTER

4.1.2.1 The Photometrics 3000 computer is based around a camera controller, image memory, video memory, and 68020 microprocessor. An internal bus interconnects the system.

4.1.2.2 The camera controller provides the interface between the Photometrics 3000 computer and the CE200/IC200. A microprogrammed state machine generates timing and control sequences in response to commands transferred from the CPU over the internal bus. The camera controller card also provides DMA transfer of image data from the CE200/IC200 to the image memory.

4.1.2.3 The image memory permits the storage of multiple frames in the Photometrics 3000 computer. The video memory provides an RS170-compatible video display of the image data. The display is 640 x 480 pixels with 8 bits of gray scale per pixel. In addition, a 1 bit 640 x 480 graphics plane is included.

4.1.2.4 Camera exposures can be commanded by the computer or synchronized with a signal commanded from an external trigger input to the camera controller.

4.1.2.5 A set of unregulated power supplies located in the computer provides operating power for the IC200 or for the CE200 and CCD camera head.

4.1.2.6 The Photometrics 3000 computer is connected to the CE200/IC200 by a single multiwire cable that may be up to 200 feet in length. The computer provides all commands, timing, and power for the camera head, excluding the power to the thermoelectric cooler.

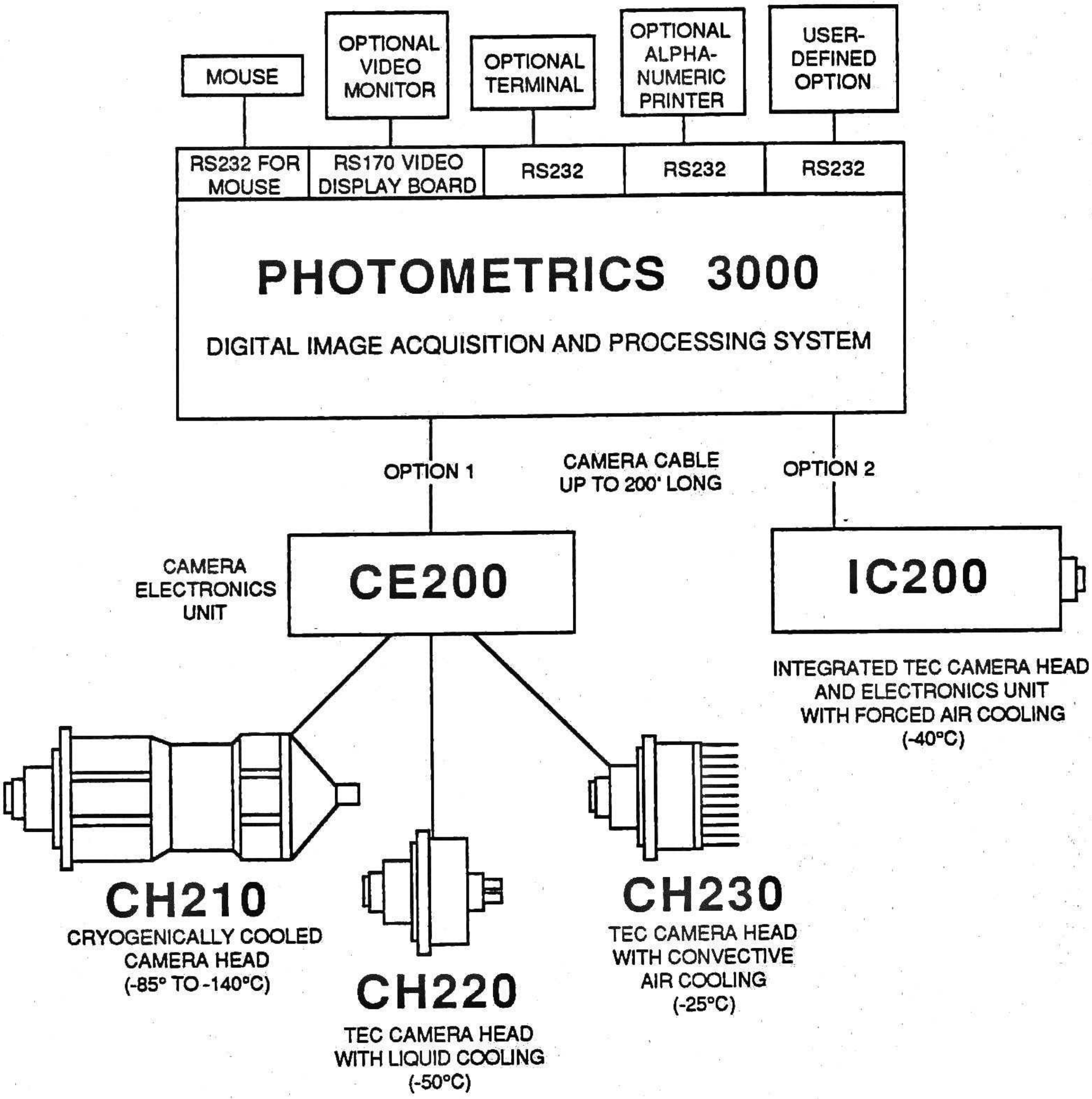

MOUSE
OPTIONAL VIDEO MONITOR
OPTIONAL TERMINAL
OPTIONAL ALPHA-NUMERIC PRINTER
USER-DEFINED OPTION
RS232 FOR MOUSE
RS170 VIDEO DISPLAY BOARD
RS232
RS232
RS232
PHOTOMETRICS 3000
DIGITAL IMAGE ACQUISITION AND PROCESSING SYSTEM
OPTION 1
CAMERA CABLE UP TO 200' LONG
OPTION 2
CAMERA ELECTRONICS UNIT
CE200
IC200
INTEGRATED TEC CAMERA HEAD AND ELECTRONICS UNIT WITH FORCED AIR COOLING (-40°C)
CH210
CRYOGENICALLY COOLED CAMERA HEAD (-85° TO -140°C)
CH220
TEC CAMERA HEAD WITH LIQUID COOLING (-50°C)
CH230
TEC CAMERA HEAD WITH CONVECTIVE AIR COOLING (-25°C)

Figure 4-1. Photometrics 3000 System: Options 1 and 2

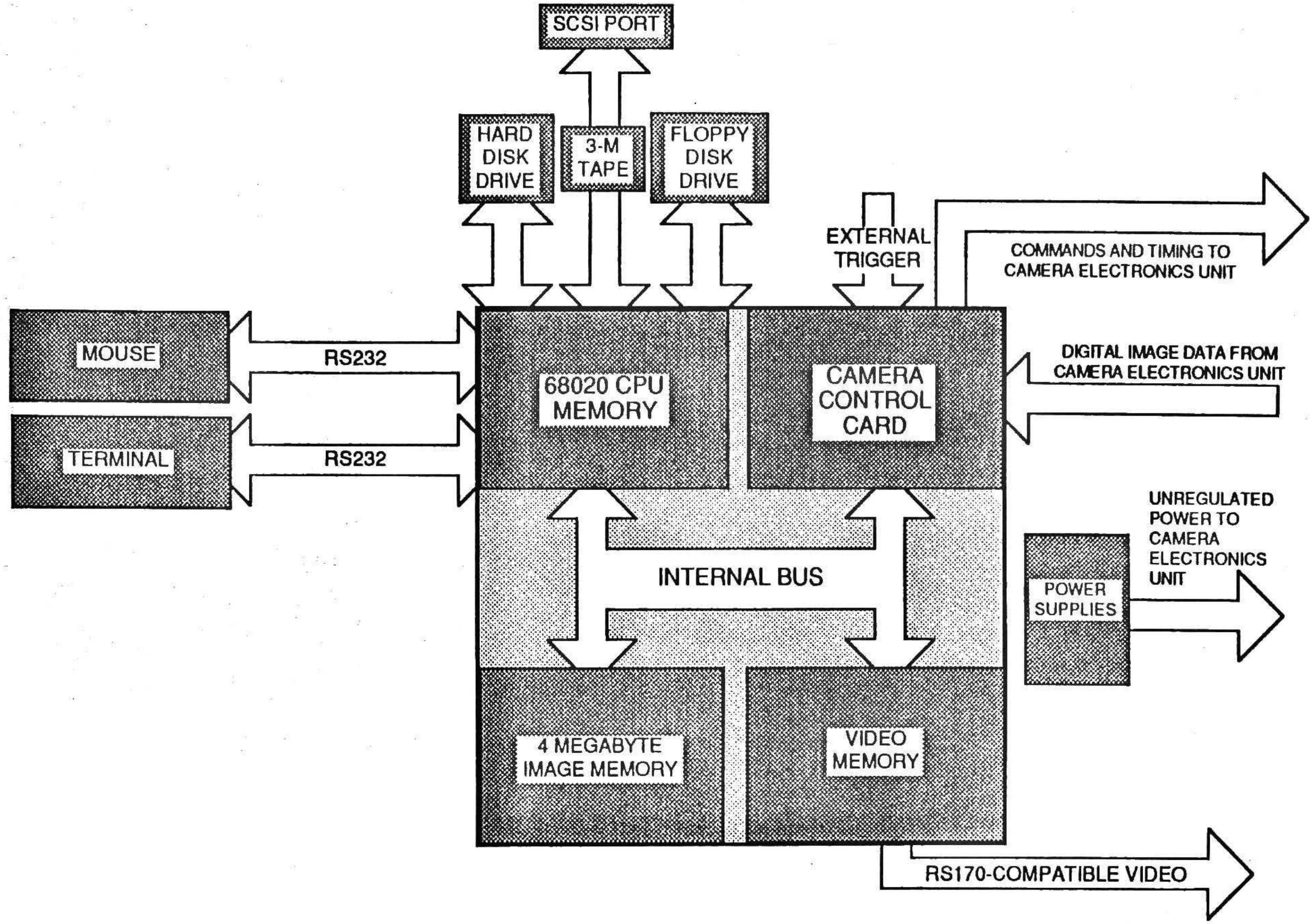


Figure 4-2. Photometrics 3000 Computer

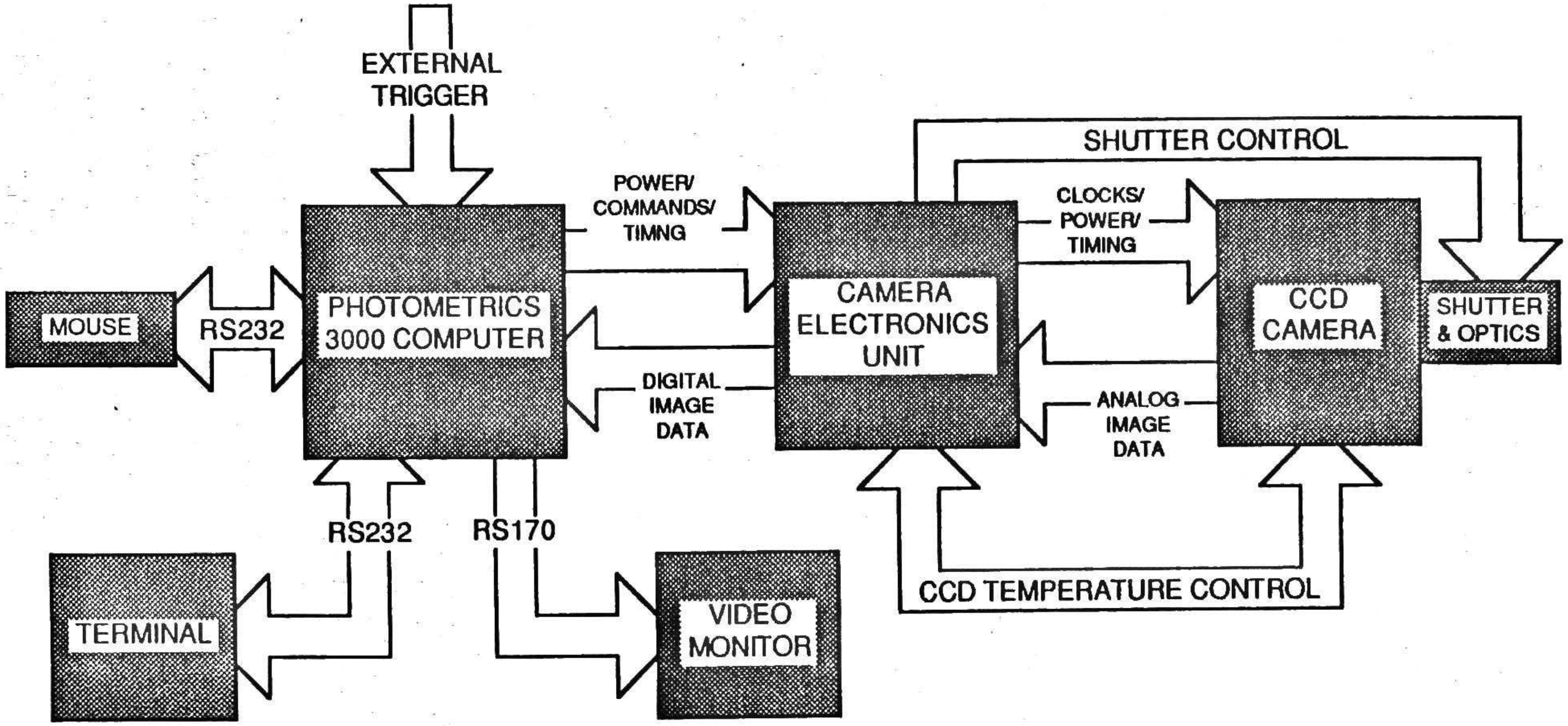


Figure 4-3. System Functions

4.1.3 CE200 CAMERA ELECTRONICS UNIT

4.1.3.1 The CE200 provides power for the camera electronics and cooling control system and produces CCD clocking signals. Figure 4-4 is a block diagram of CE200 functions.

4.1.3.2 The CE200 contains signal processing circuitry to amplify the image signal from the CCD and provide noise filtering. Analog-to-digital conversion changes the processed analog image signal to digital format. CCD analog image signals from the camera head are processed by one of two techniques. Slow analog sampling, with a sampling rate of up to 50 kHz, uses a double-correlated integration sampling scheme. Fast analog sampling, with a sampling rate of up to approximately 200 kHz, uses a fixed lowpass filter. In both cases, the signal processing includes DC restoration circuitry to provide a reference level.

4.1.3.3 CCD temperature control is established by a closed loop control system that uses a temperature sensing diode located in the CCD camera head. AC line power must be supplied to the CE200 to operate a cooling fan and to provide power for the thermoelectric coolers in the CH220 and CH230 camera heads.

4.1.3.4 Digital commands and timing signals from the camera controller are received by a set of digital receivers in the CE200. Digital transmitters in the CE200 send the converted image data to the computer, which can be located up to 200 feet away. CE200 voltage regulators take unregulated power supplied by the computer and provide regulated voltages to operate the CE200 circuitry and the CCD camera head.

4.1.3.5 Shutter control circuitry that responds to commands from the computer is also located in the CE200.

4.1.4 CCD CAMERA HEAD

Photometrics CCD camera heads are composed of image forming optics, a shutter, the CCD detector and its associated cooler, and a preamplifier which raises the CCD output signal to a high level and drives the connecting cable to the CE200. Figure 4-5 is a block diagram of a Photometrics CCD camera head.

4.1.5 PERIPHERALS

4.1.5.1 Disk Drives

4.1.5.1.1 The Model 3000 computer has two disk drives enclosed in its housing. The 5 1/4-inch floppy disk drive is used for system software installation and backup; the 5 1/4-inch Winchester disk drive boots up the system after installation of the system software and stores CCD image data.

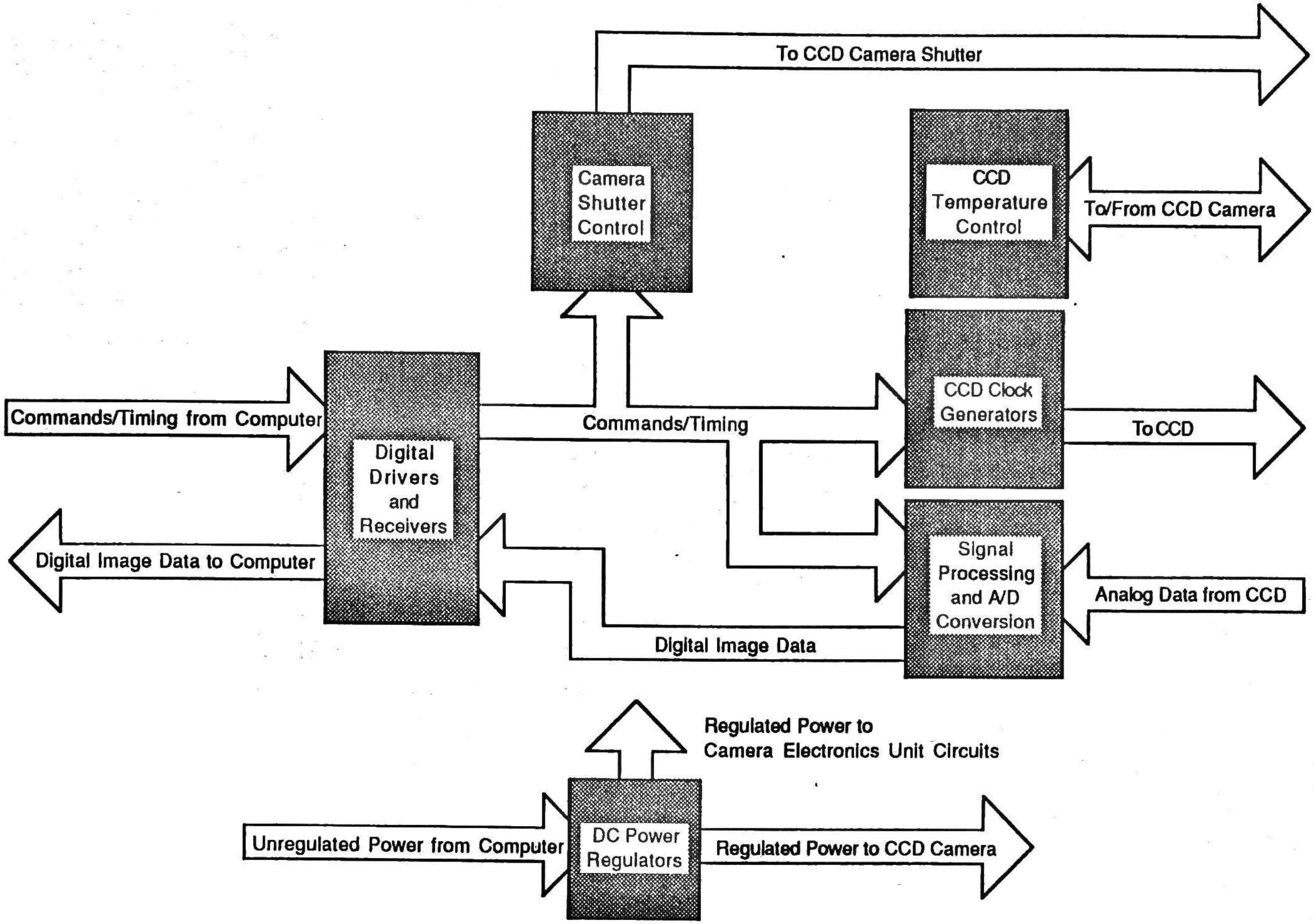

To CCD Camera Shutter
Camera Shutter Control
CCD Temperature Control
To/From CCD Camera
Commands/Timing from Computer
Digital Drivers and Receivers
Commands/Timing
CCD Clock Generators
To CCD
Digital Image Data to Computer
Signal Processing and A/D Conversion
Analog Data from CCD
Digital Image Data
Regulated Power to Camera Electronics Unit Circuits
Unregulated Power from Computer
DC Power Regulators
Regulated Power to CCD Camera

Figure 4-4. CE200 Camera Electronics Unit

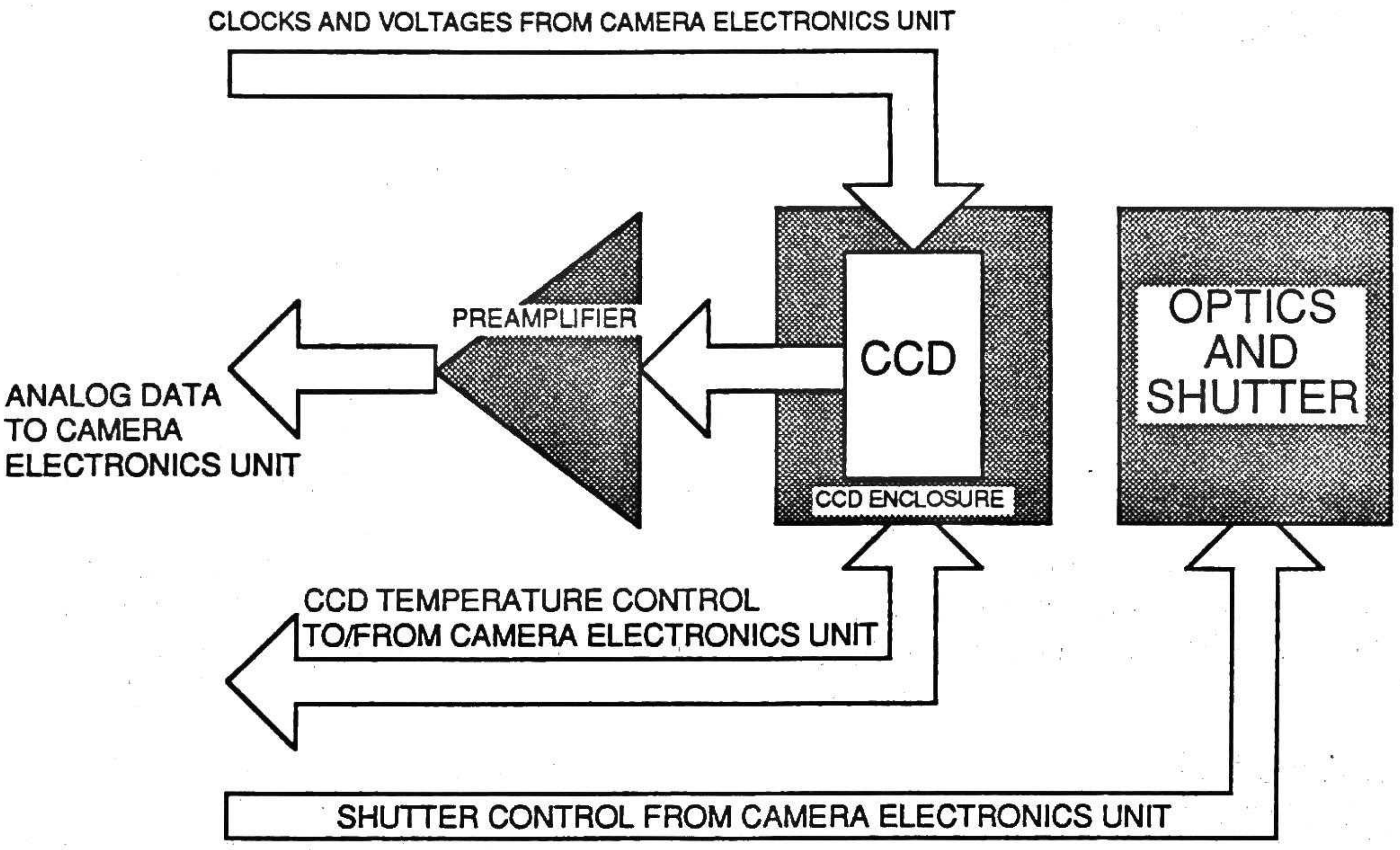

CLOCKS AND VOLTAGES FROM CAMERA ELECTRONICS UNIT
PREAMPLIFIER
ANALOG DATA
TO CAMERA
ELECTRONICS UNIT
CCD
CCD ENCLOSURE
OPTICS
AND
SHUTTER
CCD TEMPERATURE CONTROL
TO/FROM CAMERA ELECTRONICS UNIT
SHUTTER CONTROL FROM CAMERA ELECTRONICS UNIT

Figure 4-5. CCD Camera Head

4.1.5.1.2 The floppy disk drive [720 Kbyte (formatted), 96 tracks per inch] requires the use of double-sided, double-density 5 1/4-inch diskettes.

4.1.5.1.3 The standard Winchester disk drive is a 55 Mbyte (unformatted) 5 1/4-inch disk drive with an SCSI to ST506 controller mounted on the computer chassis. An optional 140 Mbyte drive is available.

4.1.5.2 Graphics Terminal

If a graphics or non-graphics video terminal and keyboard were supplied with your system, an operating manual and connecting cable were shipped in the packing box with the terminal.

4.1.5.3 1/4-Inch Tape Drive

4.1.5.3.1 The 40 mbyte 1/4-inch tape cartridge must be formatted with **mtformat** before use. Formatting takes approximately 40 minutes; preformatted tapes are available.

4.1.5.3.2 **tinit** initializes the 1/4-inch tape cartridge in order to make a new cartridge available to the user. **tinit** must be entered each time a new cartridge is inserted into the tape drive and before that drive is opened after power up.

4.1.5.3.3 The 1/4-inch tape allows random access to any recorded image. Images can be overwritten within the body of data on the tape, provided that the total number of bytes comprising the new image is the same or smaller than in the original.

4.1.5.3.4 The UNIX™ software that supports the CCD program and camera hardware is distributed on the 1/4-inch tape. This software can be copied to the Winchester disk when the system is rebuilt.

4.1.5.3.5 The 1/4-inch tape is integrated as a UNIX™ device with the name hcx. Using **/dev/hcx**, the UNIX™ file backup amd recover commands **tar** and **cpio** can write and read files. The UNIX™ dd facility also works on **/dev/hcx**, but because there is no EOF terminator, the block count must be specified.

4.2 PHOTOMETRICS 3000 COMPUTER

4.2.1 The Photometrics 3000 computer is housed in a tabletop unit and is designed around a card cage with nine card positions.

4.2.2 The following circuit boards are included as standard equipment:

- Single board 68020 computer with one megabyte of program RAM;
- Camera controller board with a DMA channel for transferring images from the camera to memory buffers;
- 640x480 pixel RS170-compatible monochrome video memory display with graphics overlay;
- Four megabyte RAM image buffer.

4.2.3 The following peripherals and camera support are also included:

- 5 1/4-inch double-sided double-density 720 kilobyte (formatted) floppy disk drive;
- 5 1/4-inch 55 megabyte (unformatted) Winchester disk drive;
- Camera interface and power to operate any Photometrics camera at a distance of up to 200 feet from the computer;
- RS232-driven mouse;
- Cartridge tape drive.

4.2.4 The following options are available:

- External 9-track tape drive;
- CRT terminal and keyboard with graphics option and 10-foot RS232 cable;
- RS170-compatible monochrome monitor with six-foot cable;
- Line printer with 10-foot RS232 cable;
- 140 megabyte (unformatted) Winchester disk upgrade.

4.2.5 CARD CAGE

4.2.5.1 The Photometrics 3000 computer contains a 9 slot card cage. The CPU and camera controller cards must be placed in card positions 2 and 3 to provide continuity for the bus grant/request signals. The physical location of the other cards is arbitrary. Additional, optional memory boards can be added to the system.

4.2.5.2 A layout of the cards is found in figure 4-6. As delivered, the complement of cards is as follows:

Position 1 -- Spare;
Position 2 -- CPU;
Position 3 -- Camera Controller;
Position 4 -- Spare;
Position 5 -- Video Display Memory;
Position 6 -- Image Memory;
Positions 7-9 -- Spare.

4.2.6 CPU

This processor board is a 68020-based single board computer with one megabyte of memory, floppy disk controller, Winchester disk SCSI port, 4 serial ports, and an additional SCSI port for general usage. The extra SCSI port controls the 3M cartridge tape and can also control an optional 1/2-inch streaming 9-track tape drive. The floppy disk controller and the general purpose SCSI boards are small daughter boards attached to the two SBX ports on the computer board. There are five ribbon cables that route signals from the edge card connectors of the CPU board to the rear panel connectors.

4.2.7 CAMERA CONTROLLER

4.2.7.1 The camera controller communicates with the CE200 or IC200. This card sends commands that cause the CE200/IC200 to initiate CCD readout, open and close the shutter, and perform other related tasks. The camera controller also receives data from the CE200/IC200 and includes a DMA channel to transfer those data to the image memory.

4.2.7.2 The camera controller is microprogrammed and can be reconfigured to control a wide range of CCD imagers by changing ROMs.

4.2.7.3 The external trigger is routed to the camera controller via a black and white twisted pair that plugs into P5. The other end terminates at a BNC connector at V4.

4.2.8 VIDEO DISPLAY MEMORY

4.2.8.1 The video display memory is a 640 by 480 element display driver. This card contains memory and video driver circuitry to enable it to produce a high resolution image of the CCD picture. Because its gray scale is only eight bits deep, a linear mapping algorithm is employed to transform the CCD pixel values to a range of values from 0 to 255 for display. A one bit (on/off) graphics plane allows plotting over the image. Refer to the Photometrics 3000 UNIX™/FORTH User's manuals for more information on these functions.

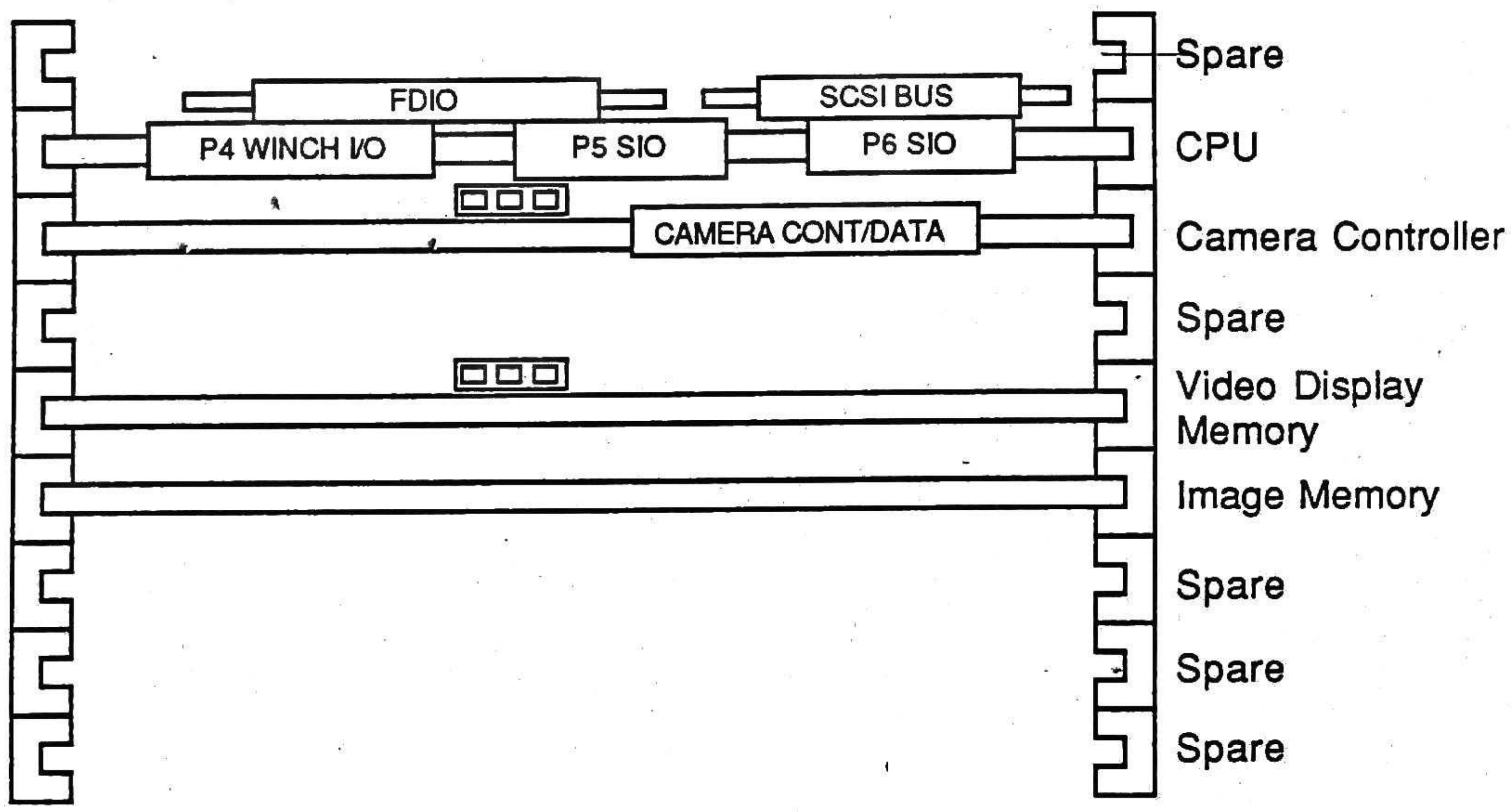


Figure 4-6. Computer Card Cage Layout

4.2.8.2 The video signal is transmitted to the rear panel via a blue and white twisted pair. The 3 position plug connects to the video display memory near the center of the card and is terminated at the rear panel with a BNC connector at V1.

4.2.9 IMAGE MEMORY

The image memory provides random access memory to store the CCD image as it is transferred from the computer. This memory allows image arithmetic to be performed with two or more full images resident in memory at the same time. Unless specified otherwise in Section 3.0, the image memory is shipped with its starting address set to 400000 hex.

4.3 CE200 CAMERA ELECTRONICS UNIT

4.3.1 GENERAL DESCRIPTION

4.3.1.1 The CE200 camera electronics unit provides power for the camera electronics and cooling control systems and produces CCD clocking signals for the CH210, CH220, and CH230 camera heads. Figure 4-7 provides the mechanical specifications for the CE200.

4.3.1.2 The CE200 is composed of a thermoelectric cooler power supply, temperature controller, card cage, and fan. The card cage can be equipped with one of two low noise, high dynamic range analog processor options. The option choice is driven by the application and the tradeoff between speed and dynamic range.

4.3.2 CE200 SPECIFICATIONS

Weight: 12 lb (5.5 kg)

Length: 13.25 in (33.7 cm)

Height: 6 in (15.2 cm)

Width: 6 in (15.2 cm)

Maximum distance from the computer: 200 ft (61 m)

Maximum operating temperature: 120°F (48°C)

AC line power requirements: 115 VAC or 230 VAC; +5% - 10%; 48 - 66 Hz
50 VA when used with thermoelectrically cooled camera head
7VA when used with cryogenically cooled camera head

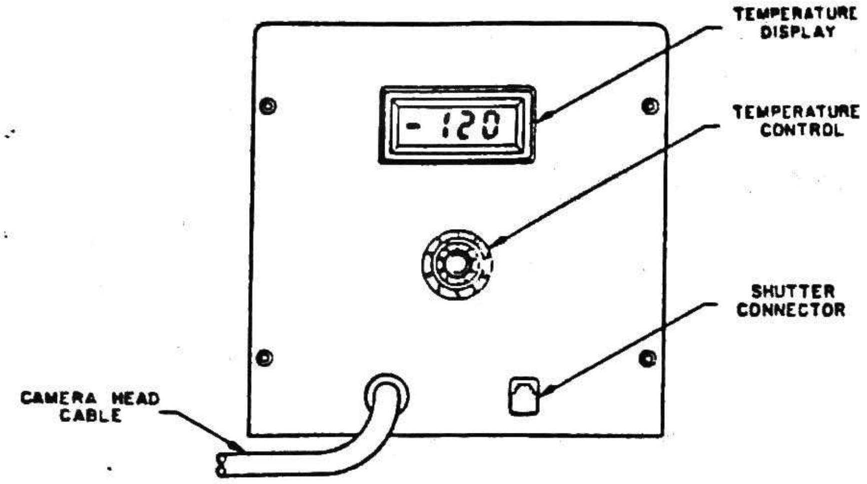
Power provided by the computer: +26 VDC @ 0.31A; -20 VDC @ 0.18A; +9VDC @ 0.85A

4.3.3 ELECTRONICS CARD CAGE

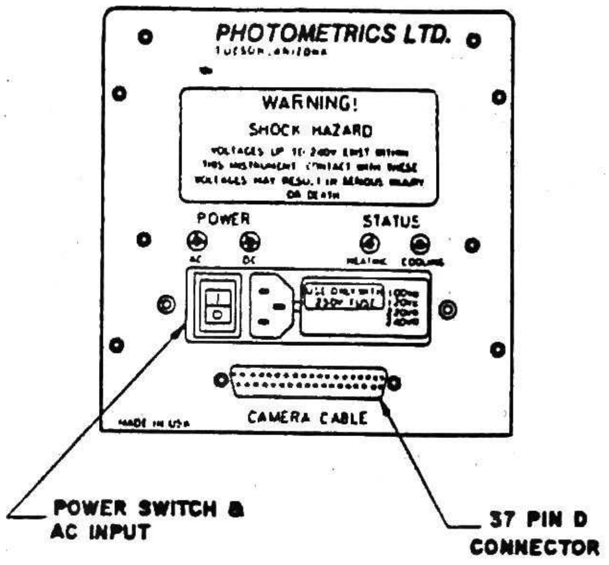
The CE200 electronics card cage contains six printed cards that are interconnected through a mother board.

4.3.3.1 Temperature and Shutter Control Card

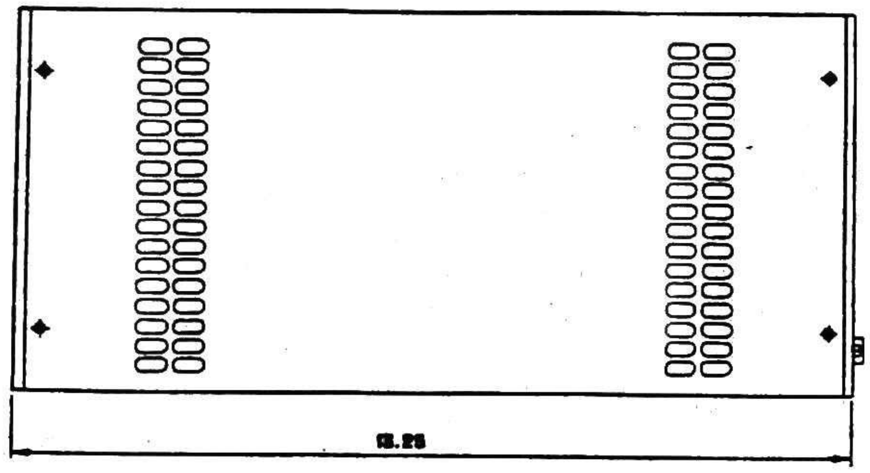
4.3.3.1.1 The temperature and shutter control card controls the temperature of the CCD and operates the shutter solenoid. The CCD is cooled by a thermoelectric cooler. A small heater used in conjunction with a temperature sensor and feedback circuit maintains the CCD at a constant temperature above the uncontrolled temperature. The feedback circuit, and, hence, thermoregulation, may be disabled by setting dipswitch SW-1 to position 0; the



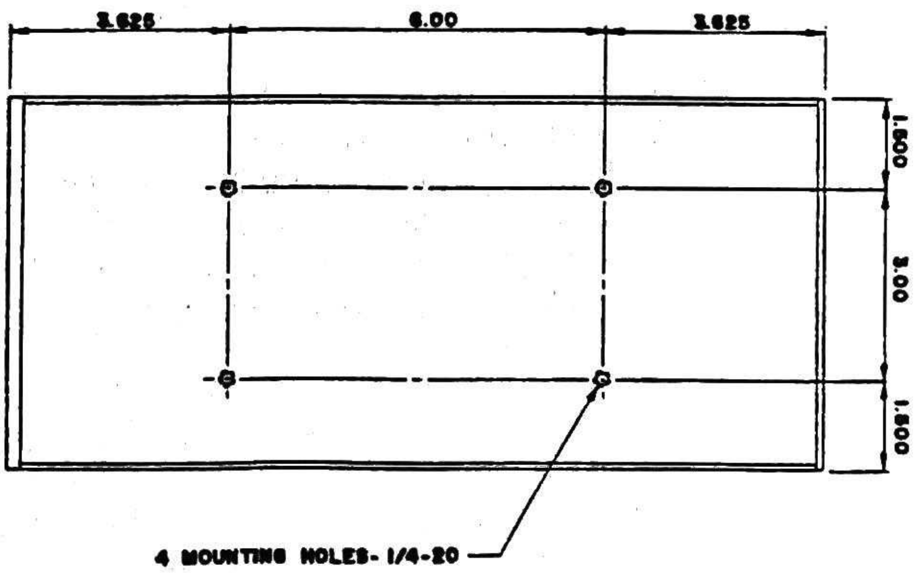
Front View
(Temperature Display & Control
Supplied Only with CH210)



Rear View



Side View



Bottom View

CE200 Mechanical Specifications

Figure 4-7

feedback circuit is activated by setting dipswitch SW-1 to position 1. *The feedback circuit should never be disabled when the CE200 is used in conjunction with the CH210 camera head.*

4.3.3.1.2 A voltmeter may be connected to pins 1 and 6 on connector P2 to monitor CCD temperature. The common should be on pin 6. The output is 10 mV/°C.

4.3.3.1.3 The two potentiometers on this card adjust the temperature setpoint and calibration. An adjustable temperature control knob and temperature display are provided on the front panel of the CE200 designed for use with the CH210 camera head. *The temperature setpoint and calibration are set at the factory for CE200 units designed for use with the CH220 and CH230 camera heads. Do not readjust these without first consulting Photometrics staff.*

4.3.3.1.4 The shutter logic signal drives a Darlington transistor to actuate the shutter.

4.3.3.2 Voltage Regulator Card

The voltage regulator card provides all of the basic voltages for the other cards and for the CCD enclosure. A connector brings power from the computer in at the top of the card. Voltage regulators produce +15, -15, +5, +5, and +23 volts. The incoming voltages are +26, -20, and +9 volts. Both of the +5 volt supplies are equipped with overvoltage crowbar devices to prevent damage to logic circuits.

4.3.3.3 Line Driver/Receiver Card

The line driver/receiver card receives differentially driven signals from the computer and decodes them into the various logic signals required by other cards in the camera. This card also has two different drivers which send serial digitized data and a clock signal to the computer.

4.3.3.4 Parallel Clock Driver Card

The parallel clock driver card receives sequenced logic signals from the line driver/receiver card and generates clock levels suitable to drive the parallel register of the CCD. This card also contains the CCD reset switch drive circuit. The clock levels can be adjusted to optimize CCD performance. *The clock levels are adjusted at the factory to optimize performance for each CCD. Do not readjust the clock level potentiometers without first consulting Photometrics staff.*

4.3.3.5 Serial Clock Driver Card

The serial clock driver card is similar to the parallel clock driver card in that it generates the correct clock levels for the CCD serial register. When commanded by the line driver/receiver card, a simple state machine sequences through a serial shift sequence. *The clock voltage levels are set at the factory to optimize performance for each CCD. Do not readjust the clock level potentiometers without first consulting Photometrics staff.*

4.3.3.6 Analog Processing Card

4.3.3.6.1 The analog processing card receives low level video signals from the CCD enclosure and amplifies, filters, and digitizes them for transmission to the computer. Two low noise, high dynamic range analog processor options are available. The option choice is driven by the application and the trade-off between speed and dynamic range. The first option uses a dual-slope integrator to subtract correlated samples before and after charge transfer to the output node of the CCD. The integrator also provides electronic bandwidth control for white and 1/f noise reduction. Intensity data are digitized to 14 bits precision at a rate of 50 kHz. The integrator has programmable integration periods to permit programmable gain operation.

4.3.3.6.2 The second analog processor option employs a clamp and sample scheme to subtract the correlated samples. A lowpass filter is used for bandwidth control. Intensity data are digitized to 12 bits precision at a rate of 200 kHz. Programmable gain is not possible with this option.

4.3.4 THERMOELECTRIC COOLER POWER SUPPLY

This power supply operates on the AC line input to the CE200 to provide thirty watts for the thermoelectric cooler. A winding on the power supply transformer provides fan power for the CE200.

4.3.5 MOUNTING HOLES

On the bottom plate of the CE200 are four 1/4-20 mounting holes arranged in a 3-inch x 6-inch rectangle.

4.3.6 BACK PANEL LIGHTS

4.3.6.1 There are four lights on the back panel of the CE200. Two are power status indicators and two are CCD temperature control status indicators.

4.3.6.2 When lit, the AC light indicates that AC power to the CE200 is on. The DC light indicates that DC power from the computer is present. A relay interlock prevents DC power from being delivered to the CE200 if AC power is switched off.

4.3.6.3 The HEATING and COOLING lights indicate the status of the CCD temperature regulation circuit. The relative brightness of these two lights varies as ambient temperature changes. When the green COOLING light is brightly lit, maximum cooling is indicated. As the operating temperature is reached, the COOLING light dims and the red HEATING light may come on.

4.3.7 CABLING

The cable connecting the CE200 to the computer may be 200 feet long. The cable connecting the CE200 to the camera head is four feet long and is attached to the CE200 so that all potentials are at ground level when connecting the camera head. An unconnected cable segment can become electrically charged and can damage the CCD sensor if connected. *Never connect or disconnect any cable while the Photometrics 3000 system is turned on.* If it is necessary to extend the cable between the CE200 and the camera head, the extension should be permanently fixed to the existing cable. Do not make a removable extension cable.

4.3.8 POWER AND LOGIC SUBREGULATION

4.3.8.1 The CE200 receives power and logic from the computer and subregulates them to the various voltages required by the camera head. AC line input is also required for the power supply and fan.

4.3.8.2 The computer provides the CE200 with all necessary DC camera voltages except that required by the camera head's thermoelectric cooler. An AC connection to the CE200 provides power for the CE200's fan and DC for the thermoelectric cooler. When the AC input (located on the backplate of the CE200) is switched off, all DC voltages from the computer are interrupted, turning the CE200 and the camera head off. This local power control allows the CE200 and the camera head to be turned off for maintenance purposes, even though the computer is still powered up.

4.3.9 CCD TEMPERATURE CONTROL

4.3.9.1 A temperature and setpoint control dial and digital readout on the frontplate of the CE200 supplied with the CH210 camera head allows the user to optimize CCD temperature. When supplied with either the CH220 or CH230 camera head, the temperature setpoint in the CE200 is hardwired to a specific level at the factory.

4.3.9.2 Temperature regulation begins when AC power is applied to the CE200; the CCD in a CH220 or CH230 camera head is cooled to a minimum temperature within 45 minutes and remains at its maximum cold temperature as long as power to the CE200 is turned on.

4.3.9.3 When the CE200 is disconnected from AC power and connected to the CH210 camera head, the CH210 cools the CCD sensor to its maximum cold temperature. When AC power is reapplied to the CE200, the temperature of the CCD stabilizes at the point set by the user through adjustment of the temperature control and setpoint dial.

4.3.9.4 The CCD in the CH210 should be operated at the highest temperature which yields acceptable dark current. For an exposure of one to two hours, set the temperature to approximately -120°C; for a ten minute exposure, set the temperature to approximately -90°C. It is not recommended that the temperature be set higher than 90°C or lower than -130°C, because long wavelength quantum efficiency and performance deteriorate with a decrease in temperature. Because dark current levels vary widely with the type of CCD used, it is not possible to give an optimal value here. A starting temperature of -110°C suffices for most applications.

4.3.9.5 The temperature and setpoint control dial has a range of one hundred degrees centigrade and is nominally calibrated to cover the range from -50°C to -150°C. The dial is graduated from 0 to 1000, with 1000 representing approximately -150°C (Table 4-1).

TABLE 4-1. CE200 TEMPERATURE SETPOINT AND CONTROL DIAL SETTINGS

DIAL SETTING	APPROX. CCD TEMPERATURE (°C)
0	-50
100	-60
200	-70
300	-80
400	-90
500	-100
600	-110
700	-120
800	-130
900	-140
1000	-150

4.4 CH210 CRYOGENIC CAMERA HEAD

4.4.1 GENERAL DESCRIPTION

4.4.1.1 The cryogenically-cooled CH210 camera head cryostat is designed for use in imaging applications where long exposures are required due to unusually low light level conditions. Two CH210 options are available: bottom-looking and side-looking. The bottom-looking and side-looking cryostats differ only in the location of their viewing window. The viewing window of the bottom-looking cryostat is located in the unit's mounting flange, while the viewing window of the side-looking cryostat is in the sidewall. Figure 4-8 provides mechanical specifications for a bottom-looking cryostat.

4.4.1.2 The CH210 reduces dark current to negligible levels with liquid nitrogen cooling. The liquid nitrogen is contained within a cryostat, sometimes called a dewar. The cryostat has a machined aluminum outer housing and a stainless steel inner flask. A radiation shield separates the outer housing from the inner flask. A copper braid connects the copper lining of the inner flask to a CCD heat sink. The heat conductivity of the copper braid balances its radiation loss to permit the CCD to reach a minimum temperature of approximately -140°C. The temperature and setpoint control dial on the CE200 camera electronics unit controls the temperature of the CCD by heating the CCD heat sink to the desired operating temperature.

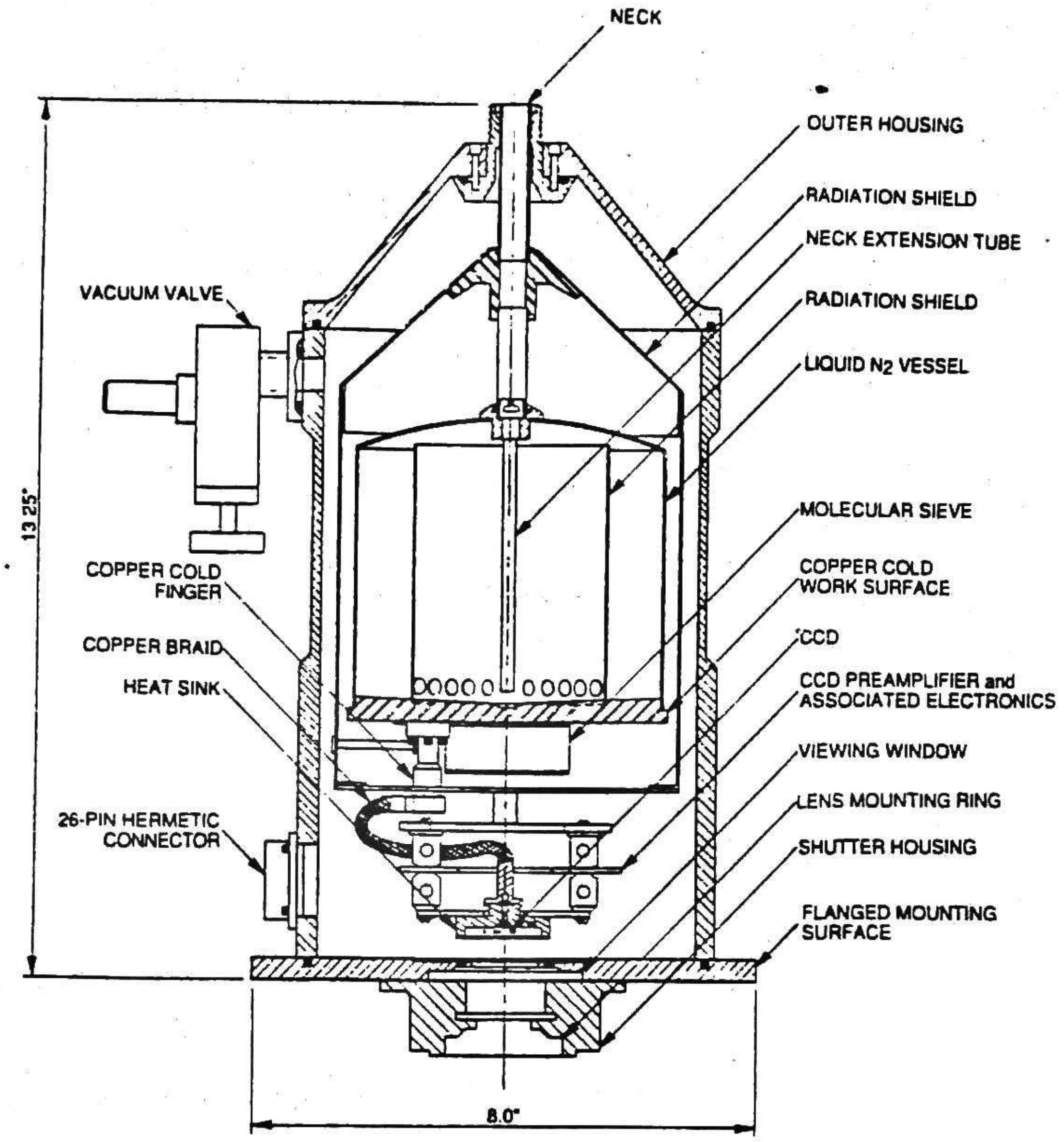
4.4.1.3 The CE200 provides signals and drive voltages required for camera head operation. In addition, the CH210 contains electronics that are directly associated with CCD operation and generates several critical voltages required by the CCD. A preamplifier raises the CCD output signal to a high level and drives the connecting cable to the camera electronics unit.

4.4.1.4 A 26-pin hermetic connector transmits voltages and signals to and from the CH210. Some of the connector pins are tied directly to CCD gates. Because static electricity can damage these gates, the shorting plug provided with the CH210 must always be installed when the camera head is not connected to the camera electronics unit.

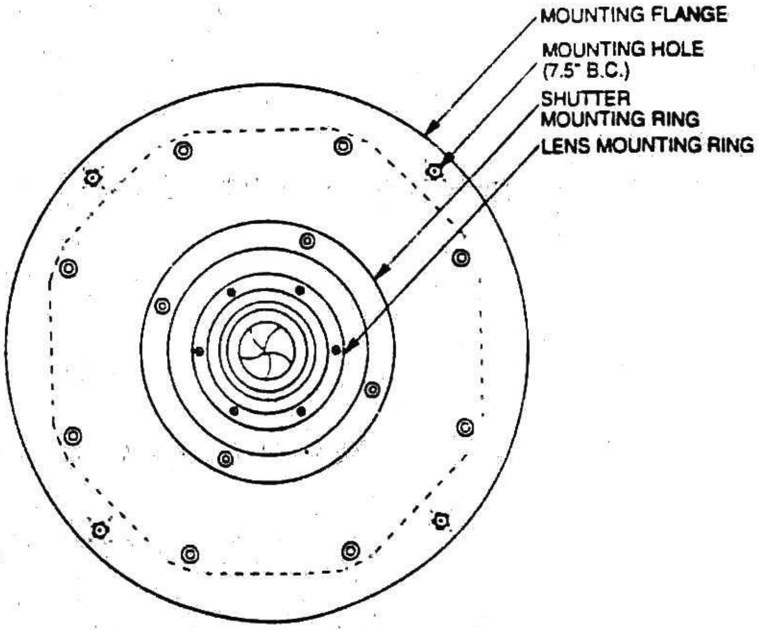
4.4.1.5 Some materials used in the construction of the CH210 outgas over the life of the cryostat. In the liquid nitrogen-cooled environment of the CH210, these gasses can condense on the face of the CCD, obscuring some pixels. A baked molecular sieve is provided as a getter to prevent the clouding of images.

4.4.1.6 The flanged mounting surface on the CH210 permits the rigid attachment of the unit to an instrument while maintaining optical alignment in any orientation.

4.4.1.7 The CH210 camera head cryostat is shipped from the factory with a support rod in its neck to prevent damage to the fragile stainless steel filling stem during shipping. *The support rod must always be installed when the cryostat is moved or shipped to another location.*



Cutaway Side View



Bottom View Showing Mounting Surface

Bottom-Looking CH210 Cryostat Mechanical Specifications
Figure 4-8

4.4.2 CCD TEMPERATURE CONTROL

4.4.2.1. The CE200 contains circuitry to operate both the CCD and the temperature control system. A temperature and setpoint control dial, located on the frontplate of the CE200, allows the user to optimize CCD temperature.

4.4.2.2 The CCD should be operated at the highest temperature which yields acceptable dark current. For exposures of one to two hours, set the temperature to approximately -120°C; for a ten minute exposure, set the temperature to approximately -90°C. It is not recommended that the temperature be set higher than 90°C or lower than -130°C, because long wavelength quantum efficiency and performance deteriorate with a decrease in temperature. Because dark current levels vary widely with the type of CCD used, it is not possible to give an optimal value here. A starting temperature of -110°C suffices for most applications.

4.4.2.3 The temperature and setpoint control dial has a range of one hundred degrees centigrade and is nominally calibrated to cover the range from -50°C to -150°C. The dial is graduated from 0 to 1000 with 1000 representing -150°C. See section 4.3.9 for further information on temperature control dial settings.

4.4.3 CH210 SPECIFICATIONS

Note: BL = Bottom-looking cryostat
SL = Side-looking cryostat

Camera body weight, excluding shutter & lens: BL = 15.6 lb (7.1 kg)

Shutter weight (BL/SL): 0.5 lb (0.22 kg)

Lens weight (BL/SL): 0.33 lb (0.15 kg)

BL length, excluding shutter & lens: 13.25 in (33.6 cm)

BL length, including shutter & lens: 16 in (40.6 cm)

SL length: 13.5 in (34.3 cm)

BL body diameter: 7.0 in (17.8 cm)

SL body diameter, excluding shutter and lens: 6.6 in (16.8 cm)

Mounting flange diameter (BL/SL): 8.0 in (20.3 cm)

Mounting holes (BL/SL):0.25 in (0.63 cm) clearance on 7.5 in (19.1 cm) bolt circle

Distance between exterior surface of mounting flange & CCD image plane (BL/SL): 0.5 in (1.3 cm)

Liquid nitrogen flask capacity, BL/SL (neck extension tube not installed, cryostat upright): 1.0 liter

Liquid nitrogen flask capacity, BL/SL (neck extension tube installed, cryostat upright or inverted): 1.0 liter

Liquid nitrogen flask capacity, BL/SL (neck extension tube installed, cryostat on its side): 0.5 liter

Cryogen boil off rate (BL/SL): liter/24 hrs after initial filling and cool down; vented filling tube provided

Sensor temperature (BL/SL): -80°C to -140°C adjustable to within two degrees and stable to within 0.1°C over ambient temperature range of 20°C

Maximum separation of cryostat & CE200 (BL/SL): 4 ft (1.2 m)

Input window (BL/SL): Fused silica with broad band AR coating (wedge window optional)

Shutter (BL/SL): Electronically actuated, 5 msec open and close times, 1 in aperture

Lens (BL/SL): Standard Pentax bayonet mount, 50 mm, f/2.0

4.4.4 FILLING THE CH210 CAMERA HEAD CRYOSTAT

Instructions for filling the cryostat are found in section 2.1.

4.4.5 EVACUATING THE CH210 CAMERA HEAD CRYOSTAT

4.4.5.1 When to Evacuate the CH210 Camera Head Cryostat

The entire cryostat is under vacuum, except for the liquid nitrogen vessel. The cryostat has undergone several pumping cycles prior to delivery and should not require attention for at least six months after it is put into service. Corrective action must be taken when the vacuum is degraded, either by a leak or by residual outgassing. The best indicator of the cryostat's vacuum condition is its *cryogen hold time*, the length of time liquid nitrogen remains in the cryostat after filling. When filled and cooled with one-half liter of liquid nitrogen, the cryogen hold time should be ten hours or more. Pump the cryostat If the cryogen hold time drops to less than six hours.

4.4.5.2 Precautions

4.4.5.2.1 The cryostat should be evacuated only by personnel experienced with vacuum systems.

4.4.5.2.2 The cryostat has a vacuum valve to permit pumping. *Never open the vacuum valve when the cryostat is cold. Opening the vacuum valve of a cold cryostat results in contamination to the interior of the cryostat and damage to the CCD by inrushing air and moisture.* If the vacuum valve is inadvertantly opened for pumping when the cryostat is cold, do not close the vacuum valve until the cryostat has reached room temperature, approximately 24 hours later. *If the valve is closed when the cryostat is cold, the internal pressure of the cryostat rises as in a pressure cooker with the warming to room temperature of the air trapped inside. This creates a very dangerous condition that can lead to personal injury if the cryostat is disassembled.* If the vacuum valve is either opened or closed when the cryostat is cold, call Photometrics Ltd. at 602/623-8961 for instructions.

4.4.5.2.3 When the cryostat is pumped, care must be taken to prevent a rapid change in pressure. If the vacuum valve is opened to the atmosphere too quickly, the inrush of air can damage the CCD.

4.4.5.3 How to Evacuate the CH210 Camera Head Cryostat

4.4.5.3.1 Empty the CH210 camera head cryostat by removing the neck extension tube, if in place, inverting the cryostat, and pouring the nitrogen out. Care should be taken to do this in a well-ventilated room. If the vacuum valve is opened while liquid nitrogen is still in the flask, violent boiling results with the attendant danger of splashing nitrogen. After the liquid nitrogen is poured out, bring the cryostat up to room temperature; this takes approximately six hours.

4.4.5.3.2 Ensure that a clean vacuum station with a pump capable of achieving a pressure of at least 10^{-4} torr (0.1 millitorr) is available. A good two stage mechanical pump with a cryogenic trap is adequate, although a turbomolecular pump is recommended. No oil can be allowed to backstream into the cryostat to contaminate the molecular sieve. If oil does contaminate the sieve, the cryostat must be returned to Photometrics for disassembly.

4.4.5.3.3 To clean out an evacuated cryostat from the effects of residual outgassing, pump out the line connecting the cryostat to the pump before opening the vacuum valve to start the pumping operation.

4.4.5.3.4 The cryostat should be at room temperature prior to pumping. *Slowly* open the vacuum valve to raise the pressure inside the cryostat to atmospheric pressure and start the pumping operation. Operate the pump for twenty-four hours to a maximum pressure of 10^{-4} torr. After pumping, close the valve on the cryostat and disconnect the cryostat from the pump.

4.5 CH220 CAMERA HEAD

4.5.1 GENERAL DESCRIPTION

The thermoelectrically-cooled CH220 camera head is intended for use with the CE200 camera electronics unit. All signals and drive voltages required for camera head operation are derived from the CE200. The CH220 is composed of a sealed CCD enclosure, shutter assembly, and lens, and is provided with a liquid-cooled heat exchanger to draw heat away from the thermoelectric cooler (figure 4-9).

4.5.2 CCD ENCLOSURE

4.5.2.1 The CCD enclosure is made up of four major components: back heat sink assembly, cylindrical flanged housing, front plate, and window assembly. These components are joined with O-ring seals to assure a good hermetic seal. The planar quartz input window has a broadband visible AR coating to assure efficient light transfer to the sensor. The enclosure is helium leak tested after assembly and baked under vacuum to remove residual materials which might adversely affect performance.

4.5.2.2 Over the life of the camera head, materials used to build the unit outgas. A baked molecular sieve is provided as a getter to absorb these outgassed materials. A sealed vacuum valve is provided in the event that the camera head requires repairs or repumping.

4.5.2.3 A flanged mounting surface on the CH220 permits rigid attachment of the unit to an instrument while maintaining optical alignment in any orientation.

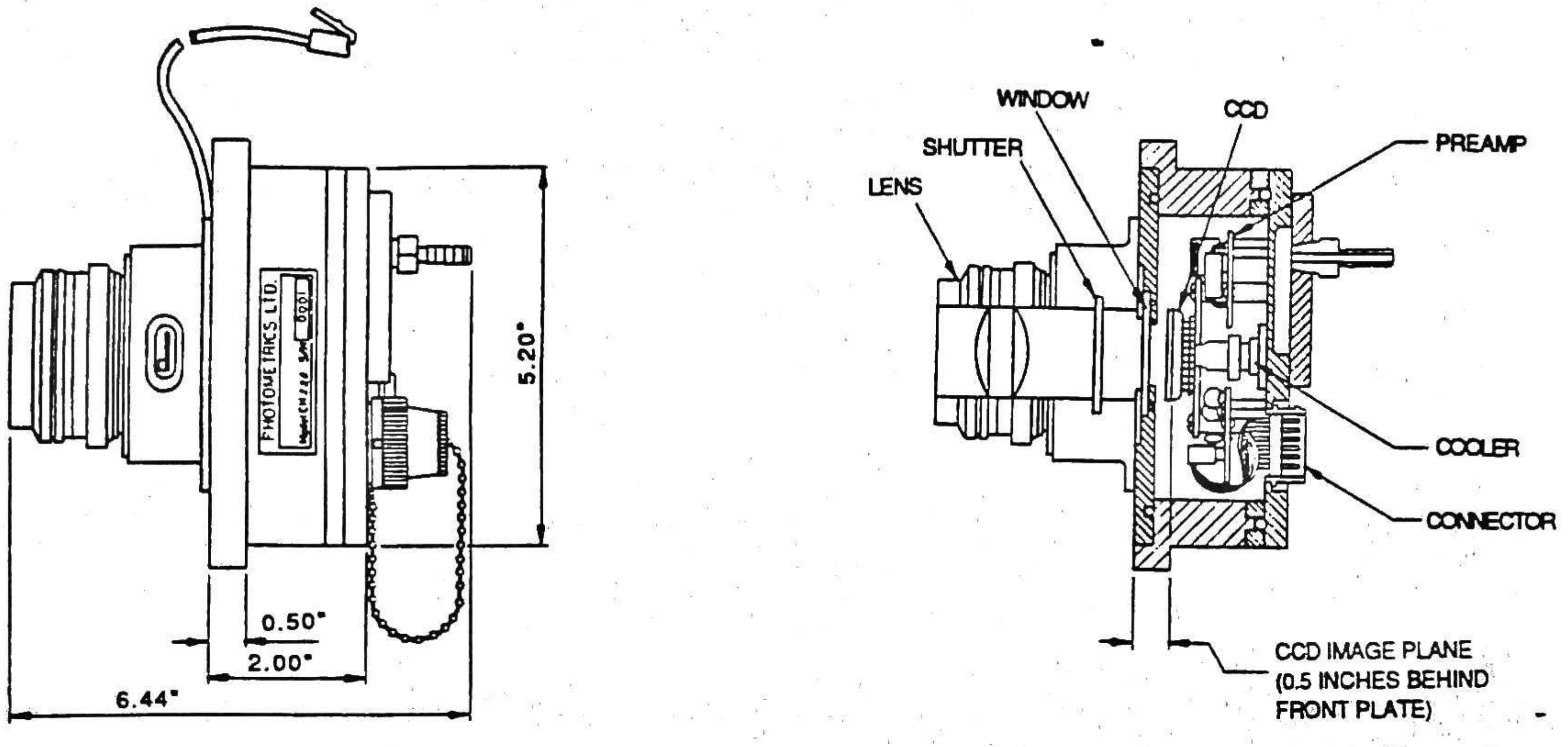
4.5.3 CH220 CAMERA HEAD

4.5.3.1 The CH220 camera head contains electronics which are directly associated with CCD operation. Several critical voltages required by the CCD are generated in the camera head. A preamplifier raises the CCD output signal to a high level and drives the connecting cable to the camera electronics unit.

4.5.3.2 A 26-pin hermetic connector transmits voltages and signals to and from the camera head. Some of the connector pins are tied directly to CCD gates. Because static electricity can damage these gates, the shorting plug provided must always be installed when the camera head is not connected to the camera electronics unit.

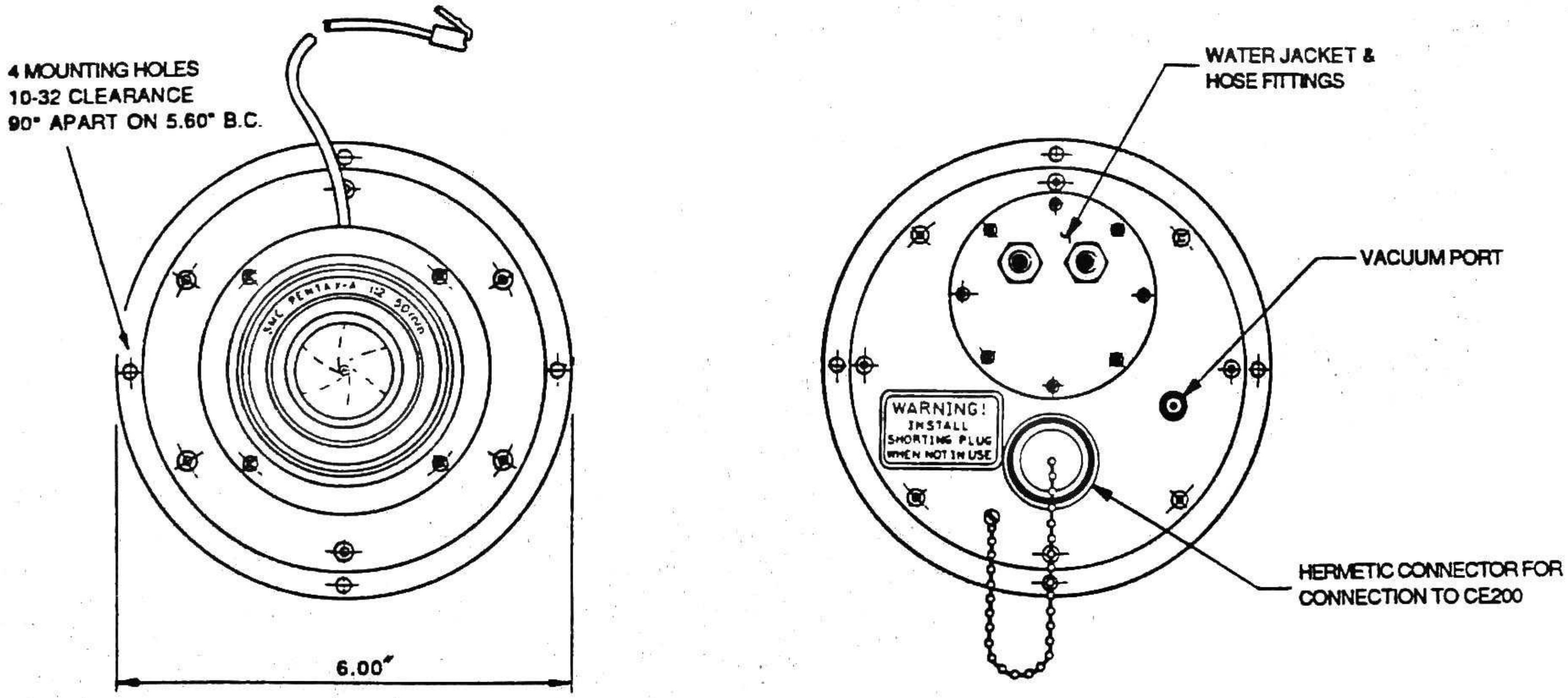
4.5.4 CCD COOLER

The CCD sensor is cooled by a three-stage thermoelectric (Peltier) cooler which is attached to a liquid-cooled heat exchanger. During normal operation, the cooler generates heat which is removed by a liquid coolant passing through the heat exchanger. *The minimum flow rate is given in the CH220 specifications which follow. If this rate is not maintained, overheating may result with*



Side View

Cutaway Side View



Front View

Rear View

CH220 Camera Head Mechanical Specifications
Figure 4-9

irreversible damage to the cooler. The sensor is cooled to -45°C while the heat exchanger is maintained at approximately the same temperature as the liquid coolant.

4.5.5 CH220 SPECIFICATIONS

Camera body weight, excluding shutter and lens: 4.0 lb (1.8 kg)

Shutter weight: 0.5 lb (0.22 kg)

Lens weight: 0.33 lb (0.15 kg)

Length, including lens and shutter: 6.4 in (16.3 cm)

Maximum body diameter (mounting flange diameter): 6.0 in (15.3 cm)

Mounting holes: No. 10 clearance on 5.60 in (14.2 cm) bolt circle

Distance between front of mounting flange and CCD image plane:
0.5 in

Suggested coolant: 10% ethylene glycol/deionized water

Maximum coolant temperature: 75°F (24°C)

Minimum coolant flow: 0.15 gallon per minute

Typical sensor operating temperatures:
-45°C for TI 4849, Thomson CSF TH7882CDA
-40°C for TI VP1M, Tektronix TK512M

Maximum separation of CH220 and CE200: 4 ft (1.2 m)

Input window: Fused silica with broad band AR coating
wedge window optional

Shutter: Electronically actuated, 5 msec open and close times

Lens: Standard Pentax bayonet mount, 50 mm, f/2.0

4.6 CH230 CAMERA HEAD

4.6.1 GENERAL DESCRIPTION

The thermoelectrically-cooled CH230 camera head is intended for use with the CE200 camera electronics unit. All signals and drive voltages required for camera head operation are derived from the CE200. The CH230 is composed of a sealed CCD enclosure, shutter assembly, and lens, and is provided with an air-cooled heat exchanger to draw heat away from the thermoelectric cooler (figure 4-10).

4.6.2 CCD ENCLOSURE

4.6.2.1 The CCD enclosure is made up of four major components: back heat sink assembly, cylindrical flanged housing, front plate, and window assembly. These components are joined with O-ring seals to assure a good hermetic seal. The planar quartz input window has a broadband visible AR coating to assure efficient light transfer to the sensor. The enclosure is helium leak tested after assembly and baked under vacuum to remove residual materials which might adversely affect performance.

4.6.2.2 Over the life of the camera head, materials used to build the unit outgas. A baked molecular sieve is provided as a getter to absorb these outgassed materials. A sealed vacuum valve is provided in the event that the camera head requires repairs or repumping.

4.6.2.3 A flanged mounting surface on the CH220 permits rigid attachment of the unit to an instrument while maintaining optical alignment in any orientation.

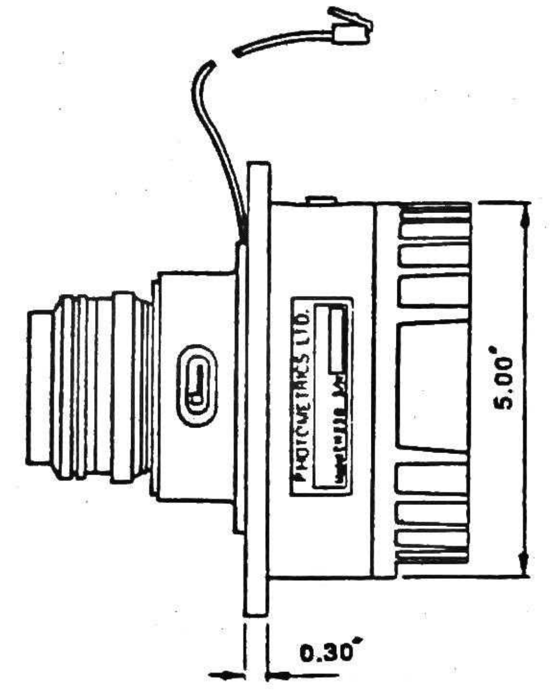
4.6.3 CH230 CAMERA HEAD

4.6.3.1 The CH230 camera head contains electronics which are directly associated with CCD operation. Several critical voltages required by the CCD are generated in the camera head. A preamplifier raises the CCD output signal to a high level and drives the connecting cable to the camera electronics unit.

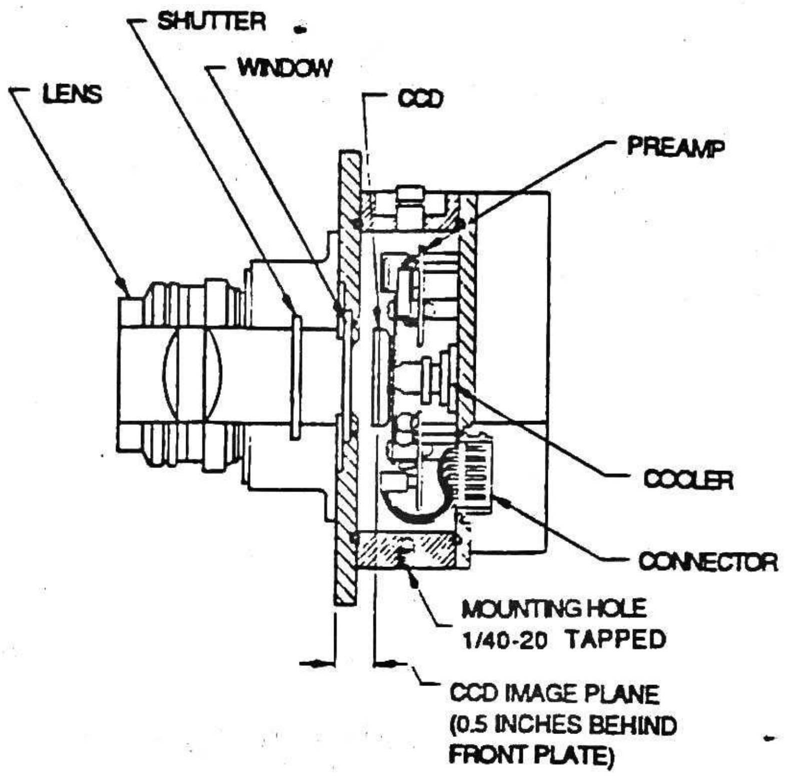
4.6.3.2 A 26-pin hermetic connector transmits voltages and signals to and from the camera head. Some of the connector pins are tied directly to CCD gates. Because static electricity can damage these gates, the shorting plug provided must always be installed when the camera head is not connected to the camera electronics unit.

4.6.4 CCD COOLER

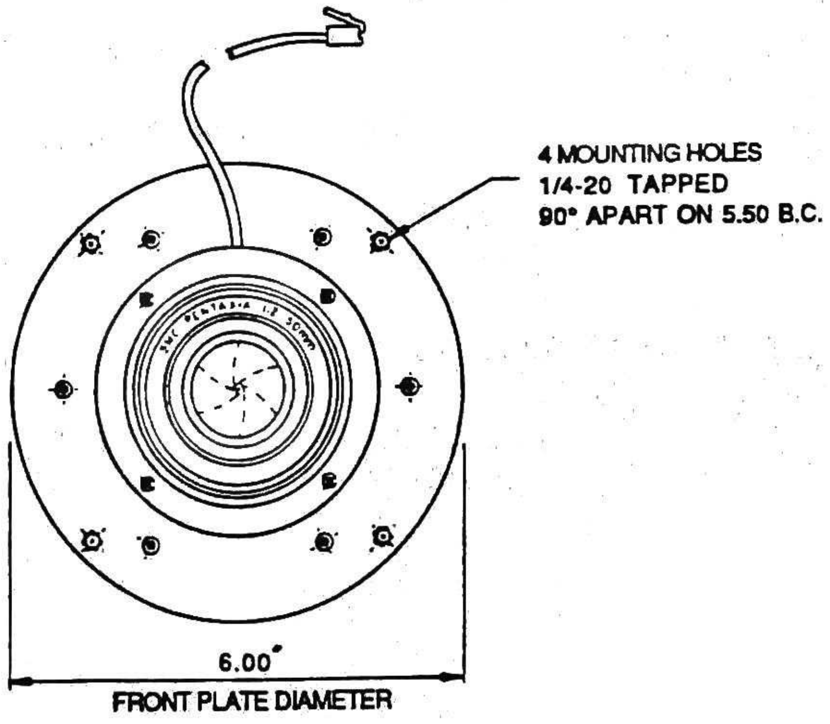
4.6.4.1 The CCD sensor is cooled to approximately -30°C by a three-stage thermoelectric (Peltier) cooler that is attached to an air-cooled heat exchanger. During normal operation, the cooler generates heat that is removed by the finned heat sink. The temperature of the heat sink may rise to 40°C. It is normal for the entire camera body to heat up slightly during operation.



Side View



Cutaway Side View



Front View

CH230 Camera Head Mechanical Specifications

Figure 4-10

4.6.4.2 Airflow around the finned heat sink assembly must never impeded. *If airflow around the camera head is cut off, permanent damage to the thermoelectric cooler results.* A fan can be used to circulate air if the camera head must be operated in a confined location.

4.6.5 CH230 SPECIFICATIONS

Camera body weight, excluding shutter and lens: 2.7 lb (1.2 kg)

Shutter weight: 0.5 lb (0.22 kg)

Lens weight: 0.33 lb (0.15 kg)

Overall length, including lens and shutter: 6.4 in (16.3 cm)

Maximum body diameter (mounting flange diameter): 6.0 in (15.3 cm)

Mounting holes: 1/4-20 thread on 5.50 in (14 cm) bolt circle

Distance between front of mounting flange and CCD image plane:
0.5 in

Typical sensor operating temperatures:
-25°C for TI 4849, Thomson CSF TH7882CDA, TI VP1M, Tektronix TK512M

Maximum ambient air temperature: 27°C

Maximum separation of CH230 and CE200: 4 ft (1.2 m)

Input window: Fused silica with broad band AR coating
wedge window optional

Shutter: Electronically actuated, 5 msec open and close times, 1 in aperture

Lens: Standard Pentax bayonet mount, 50 mm, f/2.0

4.7 IC200 INTEGRATED CAMERA HEAD AND ELECTRONICS UNIT

4.7.1 GENERAL DESCRIPTION

4.7.1.1 The IC200 integrated camera head and electronics unit combines a cooled sensor head, thermoelectric cooler power supply, clock drivers, and all analog processing and conversion electronics into one thermoelectrically cooled/forced air heat transfer unit. Figure 4-11 provides IC200 mechanical specifications. Figure 4-12 is a block diagram of major functions.

4.7.1.2 The IC200 is composed of three major assemblies: CCD enclosure, electronics card cage, and thermoelectric cooler power supply. The card cage can be equipped with one of two low noise, high dynamic range analog processor options. The option choice is driven by the application and the tradeoff between speed and dynamic range.

4.7.2 IC200 SPECIFICATIONS

Weight (including lens): 15.5 lb (7.1 kg)

Maximum length (including lens): 16.25 in (41.3 cm)

Height: 6.0 in (15.3 cm)

Width: 6.0 in (15.3 cm)

Maximum ambient temperature for optimum cooling: 75°F (24°C)

Typical sensor operating temperature (24°C ambient): -40°C

Maximum separation of IC200 and computer: 200 ft (60.7 m)

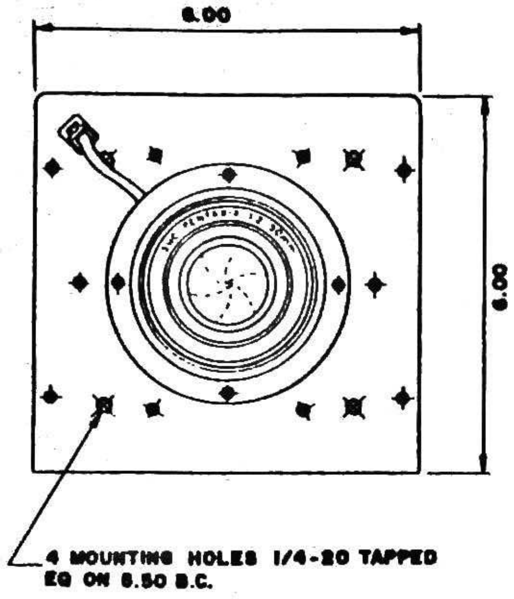
Input window: Fused silica with broad band AR coating; wedge window optional

Shutter: Electronically actuated 5 msec open, 5 msec close time

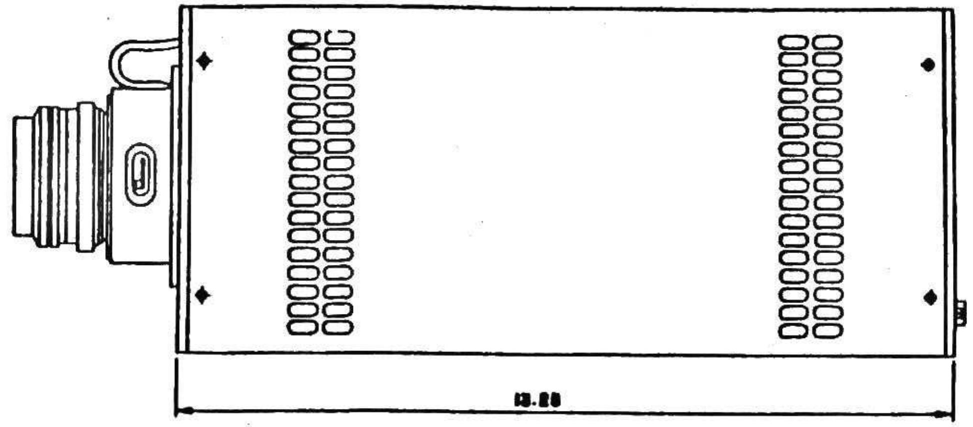
Lens: Standard Pentax bayonet mount 50 mm, f2.0 lens

AC line power requirements: 115VAC or 230VAC, +5% -10%, 48-66 Hz, 50 VA

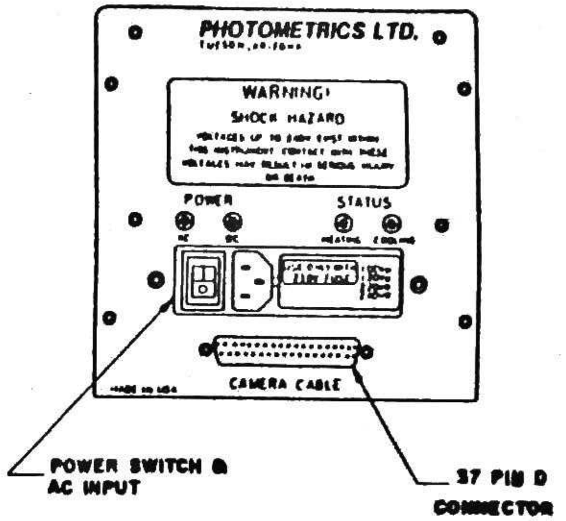
Power supplied by computer: +26 VDC @ 0.30A; -20 VDC @ 0.18A; +9 VDC @ 0.85A



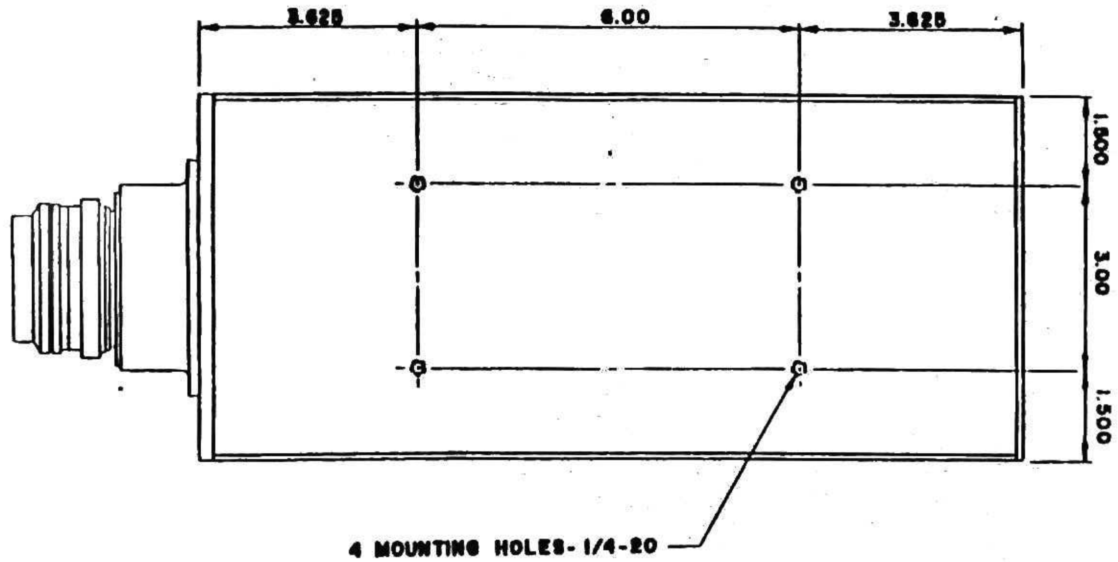
Front View



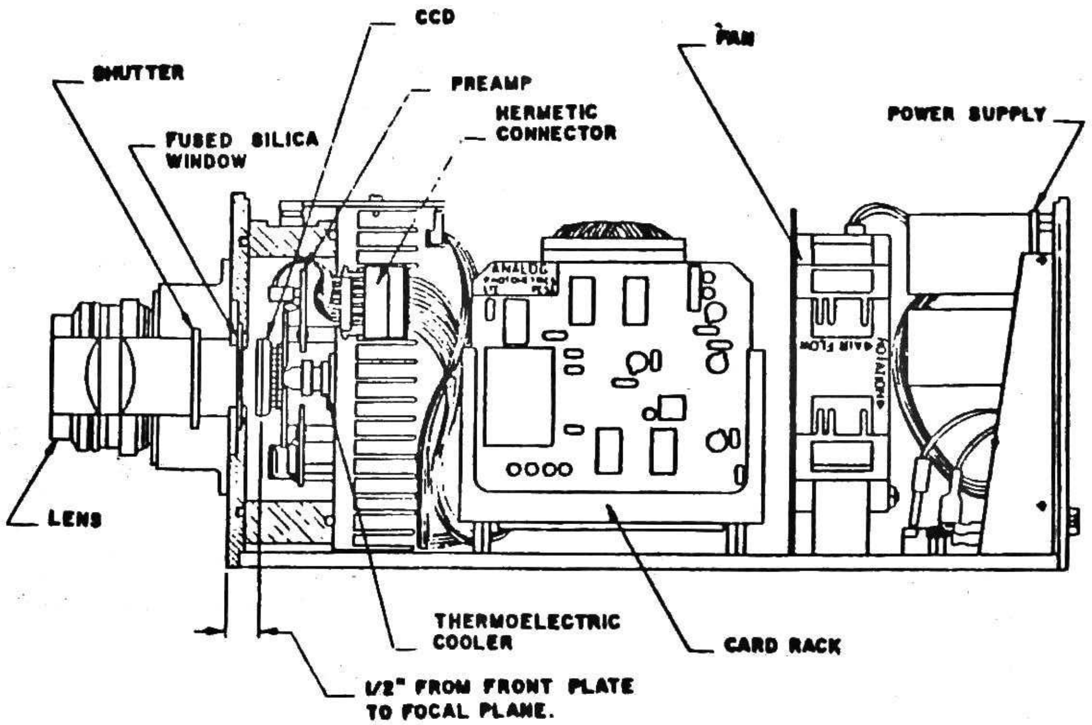
Side View



Rear View



Bottom View



Cutaway Side View

IC200 Mechanical Specifications

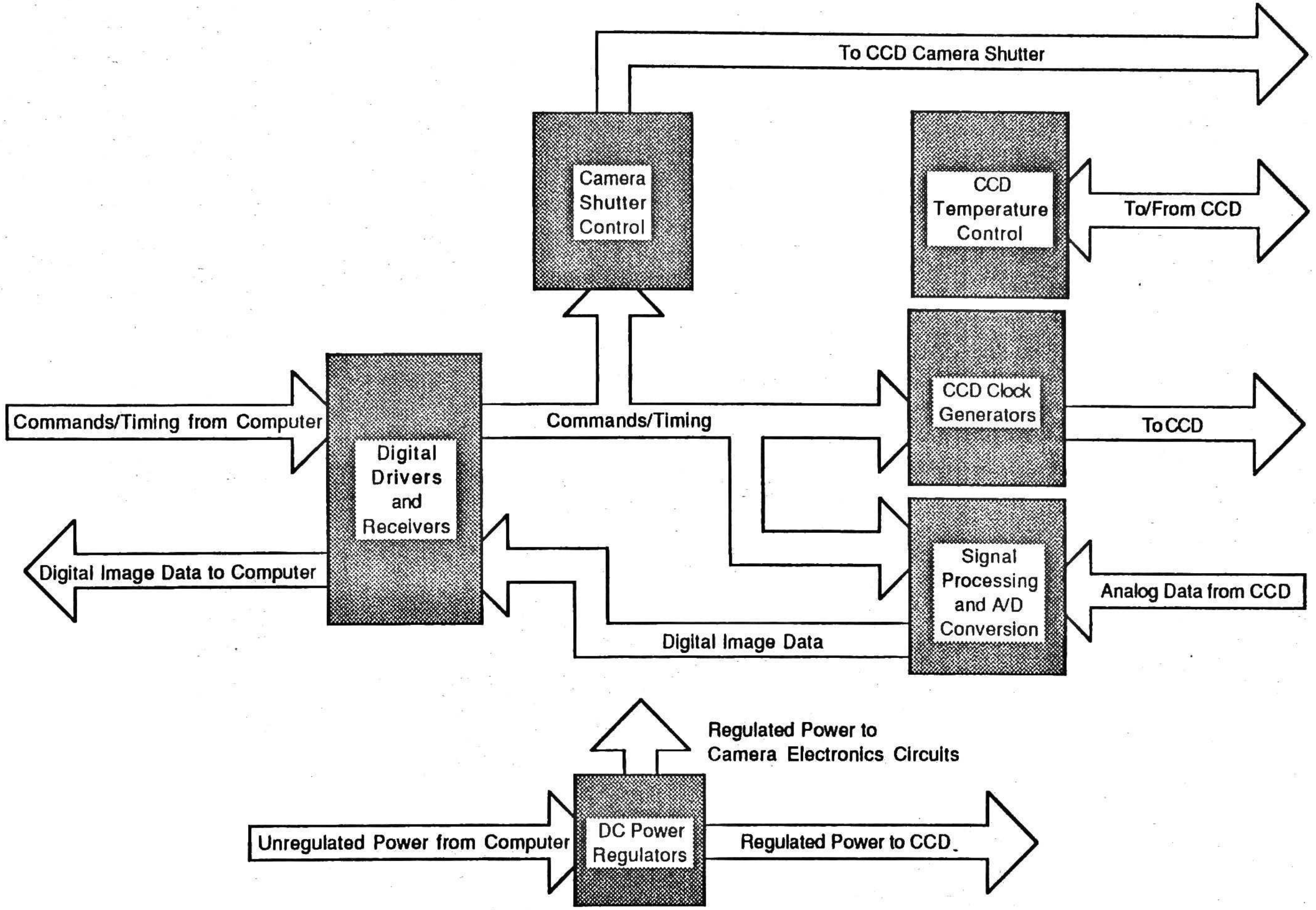

To CCD Camera Shutter
Camera Shutter Control
CCD Temperature Control
To/From CCD
Commands/Timing from Computer
Digital Drivers and Receivers
Commands/Timing
CCD Clock Generators
To CCD
Digital Image Data to Computer
Signal Processing and A/D Conversion
Analog Data from CCD
Digital Image Data
Regulated Power to Camera Electronics Circuits
Unregulated Power from Computer
DC Power Regulators
Regulated Power to CCD

Figure 4-12. IC200 Integrated Camera Head

4.7.3 CCD ENCLOSURE

4.7.3.1 The CCD enclosure is made up of four major components: back heat sink assembly, cylindrical flanged housing, front plate, and window assembly. These components are joined with O-ring seals to ensure a good hermetic seal. The planar quartz input window has a broadband visible AR coating to ensure efficient light transfer to the CCD sensor. The enclosure is helium leak tested after assembly and baked under vacuum to remove residual materials which might adversely affect performance. A getter is installed to absorb materials which outgas during the life of the camera. A sealed vacuum valve is provided in the event that the IC200 require repairs or repumping.

4.7.3.2 The CCD enclosure contains electronics which are directly associated with CCD operation. Several critical voltages required by the CCD are generated in the enclosure. A preamplifier raises the CCD output signal to a high level and drives the connecting cable to the analog processing card. A 26-pin hermetic connector transmits voltages and signals between the CCD and the electronics card cage.

4.7.4 ELECTRONICS CARD CAGE

The IC200 electronics card cage is illustrated in figure 4-13. The cage contains six printed cards that are interconnected through a mother board.

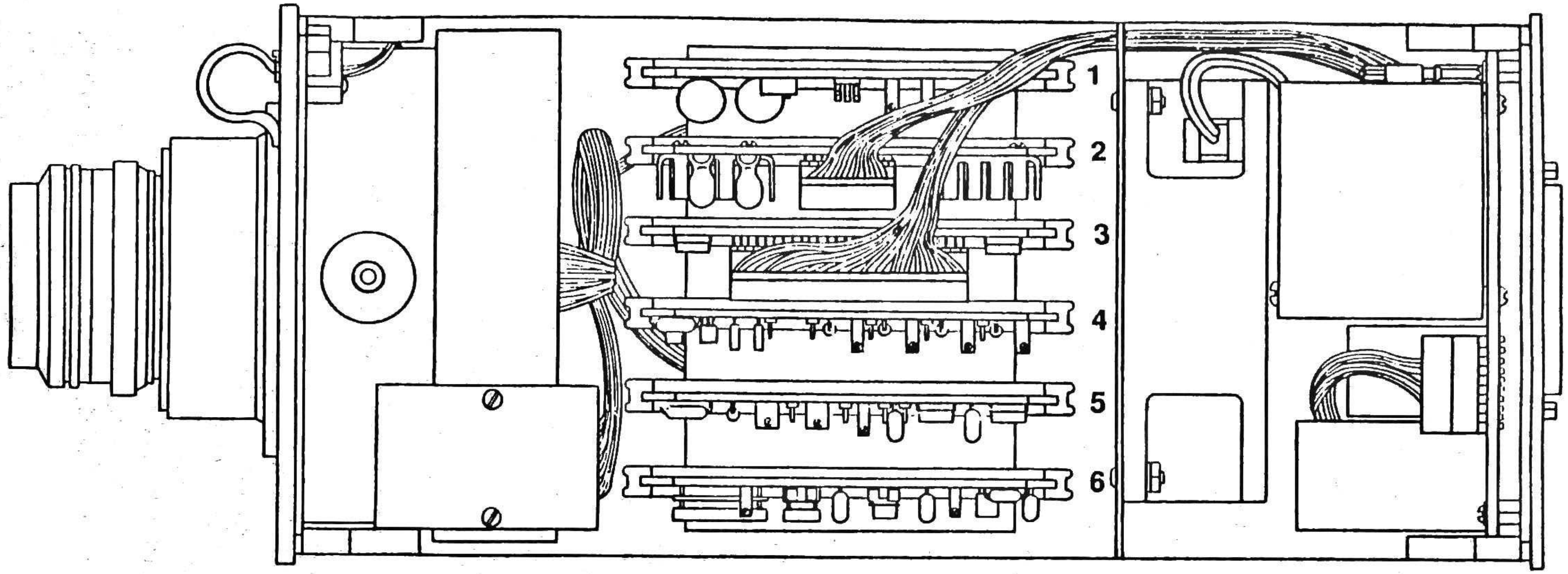
4.7.4.1 Temperature and Shutter Control Card

4.7.4.1.1 The temperature and shutter control card controls the temperature of the CCD and operates the shutter solenoid. The CCD is cooled by a thermoelectric cooler. A small heater used in conjunction with a temperature sensor and feedback circuit maintains the temperature of the CCD at approximately five degrees above the uncontrolled temperature of -45°C. The feedback circuit, and, hence, thermoregulation, may be disabled by setting dipswitch SW-1 to position 0. The feedback circuit is activated by setting dipswitch SW-1 at position 1.

4.7.4.1.2 A voltmeter may be connected to pins 1 and 6 on connector P2 to monitor CCD temperature. The common should be on pin 6. The output is 10 mV/°C.

4.7.4.1.3 The two potentiometers on this card adjust the temperature setpoint and calibration. *The temperature setpoint and calibration are set at the factory. Do not readjust these without first consulting Photometrics staff.*

4.7.4.1.4 The shutter logic signal drives a Darlington transistor to actuate the shutter.



CARD	FUNCTION
1	TEMPERATURE & SHUTTER CONTROL
2	VOLTAGE REGULATOR
3	LINE DRIVER/RECEIVER
4	PARALLEL CLOCK DRIVER
5	SERIAL CLOCK DRIVER
6	FAST ANALOG PROCESSING

Figure 4-13. IC200 Top View Showing Card Cage

4.7.4.2 Voltage Regulator Card

The voltage regulator card provides all of the basic voltages for the other cards and for the CCD enclosure. A connector brings power from the computer in at the top of the card. Voltage regulators produce +15, -15, +5, +5, and +23 volts. The incoming voltages are +26, -20, and +9 volts. Both of the +5 volt supplies are equipped with overvoltage crowbar devices to prevent damage to logic circuits.

4.7.4.3 Line Driver/Receiver Card

The line driver/receiver card receives differentially driven signals from the computer and decodes them into the various logic signals required by other cards in the camera. This card also has two different drivers which send serial digitized data and a clock signal to the computer.

4.7.4.4 Parallel Clock Driver Card

The parallel clock driver card receives sequenced logic signals from the line driver/receiver card and generates clock levels suitable to drive the CCD's parallel register. This card also contains the CCD reset switch drive circuit. The clock levels can be adjusted to optimize CCD performance. *The clock levels are adjusted at the factory to optimize performance for each system's CCD. Do not readjust the clock level potentiometers without first consulting Photometrics staff.*

4.7.4.5 Serial Clock Driver Card

The serial clock driver card is similar to the parallel clock driver card in that it generates the correct clock levels for the CCD serial register. When commanded by the line driver receiver card, a simple state machine sequences through a serial shift sequence. *The clock voltage levels on this card are set at the factory to optimize performance for each system's CCD. Do not readjust the clock level potentiometers without first consulting Photometrics staff.*

4.7.4.6 Analog Processing Card

4.7.4.6.1 The analog processing card receives low level video signals from the CCD enclosure and amplifies, filters, and digitizes them for transmission to the computer. Two low noise, high dynamic range analog processor options are available. The option choice is driven by the application and the trade-off between speed and dynamic range. The first option uses a dual-slope integrator to subtract correlated samples before and after charge transfer to the CCD's output node. The integrator also provides electronic bandwidth control for white and 1/f noise reduction. Intensity data are digitized to 14 bits precision at a rate of 50 kHz. The integrator has programmable integration periods to permit programmable gain operation.

4.7.4.6.2 The second analog processor option employs a clamp and sample scheme to subtract the correlated samples. A lowpass filter is used for bandwidth control. Intensity data are digitized to 12 bits precision at a rate of 200 kHz. Programmable gain is not possible with this option.

4.7.5 THERMOELECTRIC COOLER POWER SUPPLY

The power supply operates on the AC line input to the IC200 to provide thirty watts for the thermoelectric cooler. A winding on the power supply transformer provides fan power for the IC200.

4.7.6 MOUNTING HOLES

Two sets of mounting holes are provided. On the front plate are four 1/4-20 mounting holes which are equally spaced on a 5.5" bolt circle. On the bottom plate are four 1/4-20 mounting holes arranged in a 3" x 6" rectangle.

4.7.7 BACK PANEL LIGHTS

4.7.7.1 There are four lights on the back panel of the IC200. Two are power status indicators and two are CCD temperature control status indicators.

4.7.7.2 When lit, the AC light indicates that AC power to the IC200 is on. The DC light indicates that DC power from the computer is present. A relay interlock prevents DC power from being delivered to the IC200 if AC power is switched off.

4.7.7.3 The HEATING and COOLING lights indicate the status of the CCD temperature regulation circuit. The relative brightness of these two lights varies as ambient temperature changes. When the green COOLING light is brightly lit, maximum cooling is indicated. As the operating temperature is reached, the COOLING light dims and the red HEATING light may come on.

4.7.8 CABLING

The cable connecting the IC200 to the computer may be 200 feet long. An unconnected cable segment can become electrically charged and can damage the CCD sensor if connected. *Never connect or disconnect any cable while the system is turned on.*

4.7.9 POWER AND LOGIC

The computer provides the IC200 with all necessary DC camera voltages except that required by the thermoelectric cooler. An AC connection to the IC200 provides power for the IC200's fan and DC for the thermoelectric cooler. When the AC input (located on the backplate of the IC200) is switched off, all DC voltages from the computer are interrupted. This local power control allows the IC200 to be turned off for maintenance purposes, even though the computer is still powered up.

5.0 NOISE

5.1 NOISE SOURCES

5.1.1 The CCD camera system may be used in a variety of photometric applications. Because each application is unique, the several noise sources that affect the system should be considered in order to optimize system performance.

5.1.2 For this discussion, all noise sources are discussed in terms of electrons, the basic signal unit. Photons that penetrate the silicon lattice of the CCD produce electron hole pairs. These electrons are stored in potential wells in the CCD until readout. Thermal energy in the silicon lattice produces free electrons that are indistinguishable from electrons produced by photons. The contribution of thermally-generated charge, or dark current, may be reduced to negligible levels by cooling.

5.1.3 The noise associated with the quantity of charge stored in a potential well is called shot noise. The RMS value of shot noise may be expressed as

$$N_s = \sqrt{n}$$

where N_S is the RMS shot noise and n is the number of stored electrons.

5.1.4 If a potential well is filled to a capacity of 2.5 x 10^5 electrons, the RMS shot noise is

$$\sqrt{2.5 \times 10^5} = 500 \text{ electrons.}$$

The noise associated with dark current is calculated in the same manner.

5.1.5 Noise produced in the preamplifier, or system noise, is approximately white with a uniform spectral density over the range of 10 to 500 kHz. System noise (in electron units) may be expressed in terms of bandwidth

$$N_e = N_p \sqrt{\Delta f}$$

where N_e is the system noise, N_p is the RMS noise density in electrons per $\sqrt{\text{Hertz}}$, and Δf is the bandwidth in Hertz.

5.1.6 System noise is invariant and is the ultimate limit to low light level performance. Shot noise is proportional to the square root of the number of stored electrons and dominates system performance when the shot noise is larger than the system noise (when $N_S > N_e$).

5.1.7 Shot noise plus system noise, or total noise (N), may be written as

$$N = \sqrt{N_s^2 + N_e^2} = \sqrt{n + N_e^2}\ .$$

5.1.8 Given a photon flux of I photons per second, the total noise is

$$N = \sqrt{IQT + N_e^2}$$

where Q is the quantum efficiency and T is the integration time over which light is collected.

5.1.9 As light input increases, at some point the system noise equals the shot noise and the signal-to-noise ratio (SNR) changes from a linear function of light level to a square root function. SNR may be written as

$$SNR = \frac{IQT}{\sqrt{IQT + N_e^2}}$$

5.1.10 Other sources of coherent noise, such as dark current spikes and pixel defects, cannot be controlled. Another noise source associated with the opening of the reset switch on the CCD, KTC offset, is removed through the use of a correlated double sample in the analog processor.

5.2 KTC NOISE

5.2.1 The term KTC offset comes up frequently in the discussion of charge amplifiers and detectors which incorporate reset switches. Consider the ideal switch and ideal capacitor circuit of figure 5-1. When the switch is closed, there is zero voltage across the capacitor and no energy is stored. When the switch is opened, there should be no change and the voltage across the capacitor remains zero. The more complete model shown in figure 5-2 shows the switch resistance (R_s) and an associated Johnson output noise voltage source (e_n).

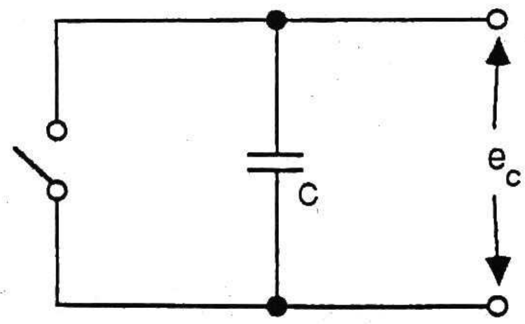


Figure 5-1. Ideal Switch Capacitor

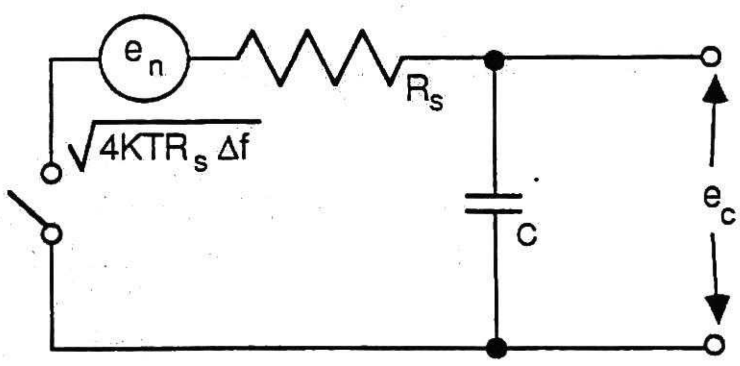


Figure 5-2. Switch and Capacitor with Johnson Noise Source

5.2.2 The output noise voltage source, e_C, is frequency limited with a 3db frequency of $\frac{1}{2\pi R_S C}$. The effective noise bandwidth for a simple RC network is $BW_{eff} = (f_{3db})(\frac{\pi}{2})$ which accounts for the decreasing response at frequencies beyond the 3db cutoff.

5.2.3 The output noise voltage is now

$$e_c = \sqrt{4KTR_s\Delta f}$$

where $\Delta f = (f_{3db})\,(\frac{\pi}{2}) = \frac{1}{4R_S C}$.

5.2.4 So,

$$e_c = \sqrt{\frac{4KTR_s}{4R_sC}} = \sqrt{\frac{KT}{C}}$$

Thus, when the switch is opened, a random voltage from a distribution with RMS value equal to $\sqrt{\frac{KT}{C}}$ remains on the capacitor.

5.2.5 The RMS voltage can be expressed in terms of RMS charge. Because $Q = CV$, then $Q_G = \sqrt{KTC}$ and, in terms of electrons RMS, the random charge is

$$N_{e-} = \frac{\sqrt{KTC}}{e-}$$

where e- is the electronic charge.

5.2.6 Note that

- the offset is independent of switch resistance;
- the offset is independent of bandwidth;
- the offset is reduced by decreasing temperature of the series resistance;
- the value calculated for KTC offset is an RMS value. Peak values are approximately six times higher and are positive or negative in sign.

5.2.7 When the gate capacitor or the output FET in a CCD is discharged by the reset pulse, KTC noise occurs by exactly the mechanism described above. That is, a random charge remains on the capacitor after the reset pulse is removed. This charge can be quite substantial, as shown in the following example.

5.2.8 Assume that the gate capacitance of a CCD is 0.3 picofarad and that the temperature is 77°K. The RMS value of the KTC is given by

$$N_{e-} = \frac{\sqrt{(1.38 \times 10^{-23})(77)(0.3 \times 10^{-12})}}{1.6 \times 10^{-19}} \sim 112 \text{ electrons RMS}$$

Since peak to peak samples from such a noise distribution can be as much as ± three times the RMS value, substantial uncertainty would result from the KTC noise. Fortunately, the architecture of the CCD allows removal of the KTC noise by appropriate signal processing.

5.2.9 While the random charge remains on the output FET gate capacitor after reset, this charge also remains after the charge from a pixel is transferred to the capacitor. In other words, the capacitor contains the sum of the charge from the pixel and the KTC noise sample after the pixel transfer. As a result, the effect of the KTC sample can be removed by subtracting the voltage at the output FET source just after reset from the voltage at the output FET source after the pixel charge has been transferred.

5.2.10 In Photometrics camera systems, signal processing is accomplished by two techniques. In the first, a "DC restore" circuit accomplishes the required subtraction. This circuit is accompanied by an analog filter to reduce the system noise bandwidth. The second technique uses a "dual slope integrator" to accomplish the required subtraction and noise bandwidth filtering.

6.0 TROUBLESHOOTING PROCEDURES

6.1 The complete camera system is a complex instrument. Care must be taken when attempting to track down a problem. The CCD sensor is especially delicate. *Because it is under vacuum, the camera head enclosure should never opened.*

6.2 If the system does not operate properly the first time it is tried, a connector may have come loose during shipping. Most camera problems can be traced to a loose cable or card. If the system fails after operating correctly for a period, a component failure is likely.

6.3 If your system fails to function, follow these troubleshooting procedures:

- Check that all cables are securely fastened and that all screwlocks are in place.
- Turn off the AC power. Remove the covers from the computer and CE200/IC200, and check for loose cables and cards. Correct any apparent problems, replace the covers, and try the system again.
- If the system still does not operate, call Photometrics maintenance staff at (602) 623–8961 in Tucson, Arizona.

CARD LAYOUTS

IC200/CE200 Temperature and Shutter Control Card

IC200/CE200 Voltage Regulator Card

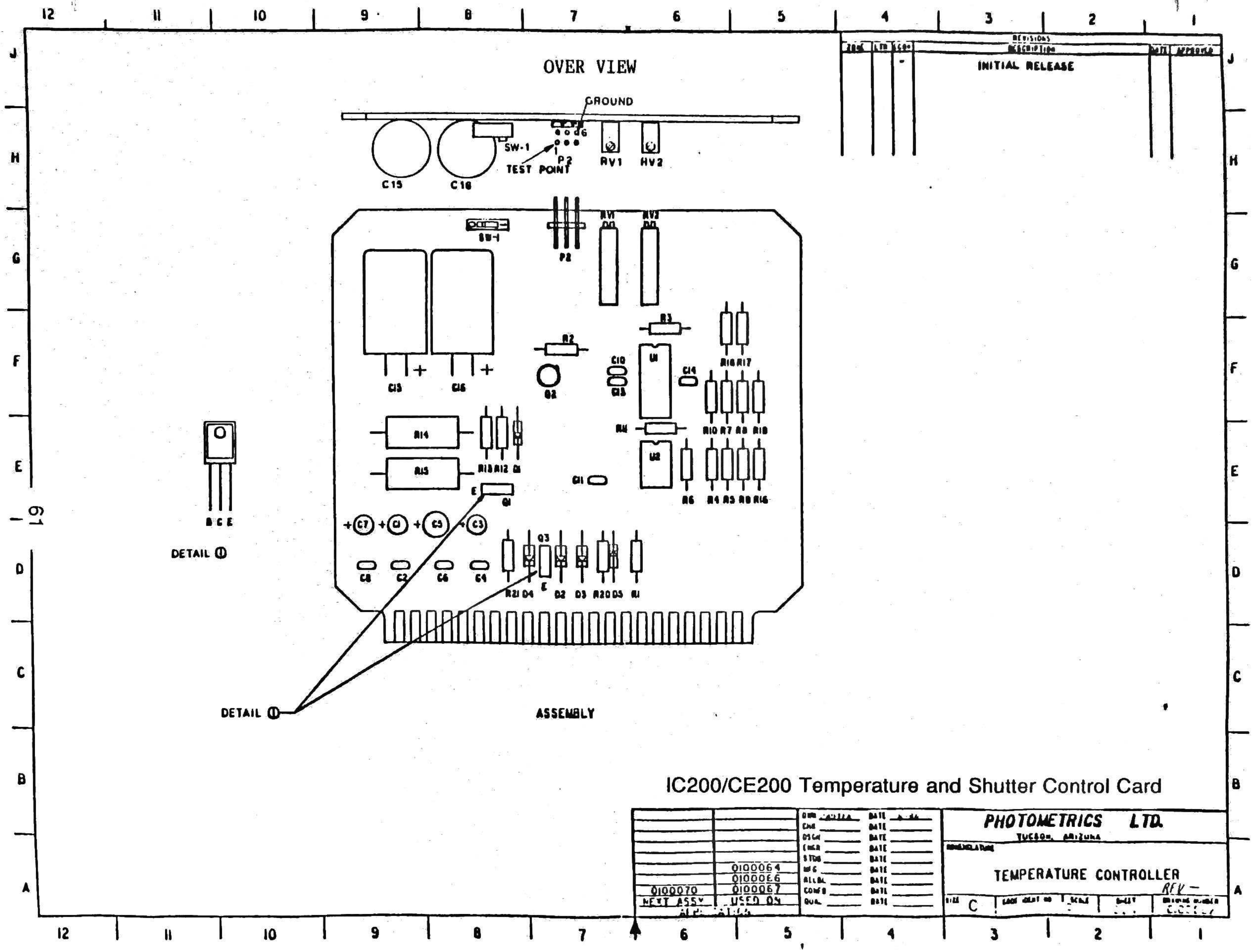
IC200/CE200 Line Driver/Receiver Card

IC200/CE200 Parallel Clock Driver Card

IC200/CE200 Serial Clock Driver Card

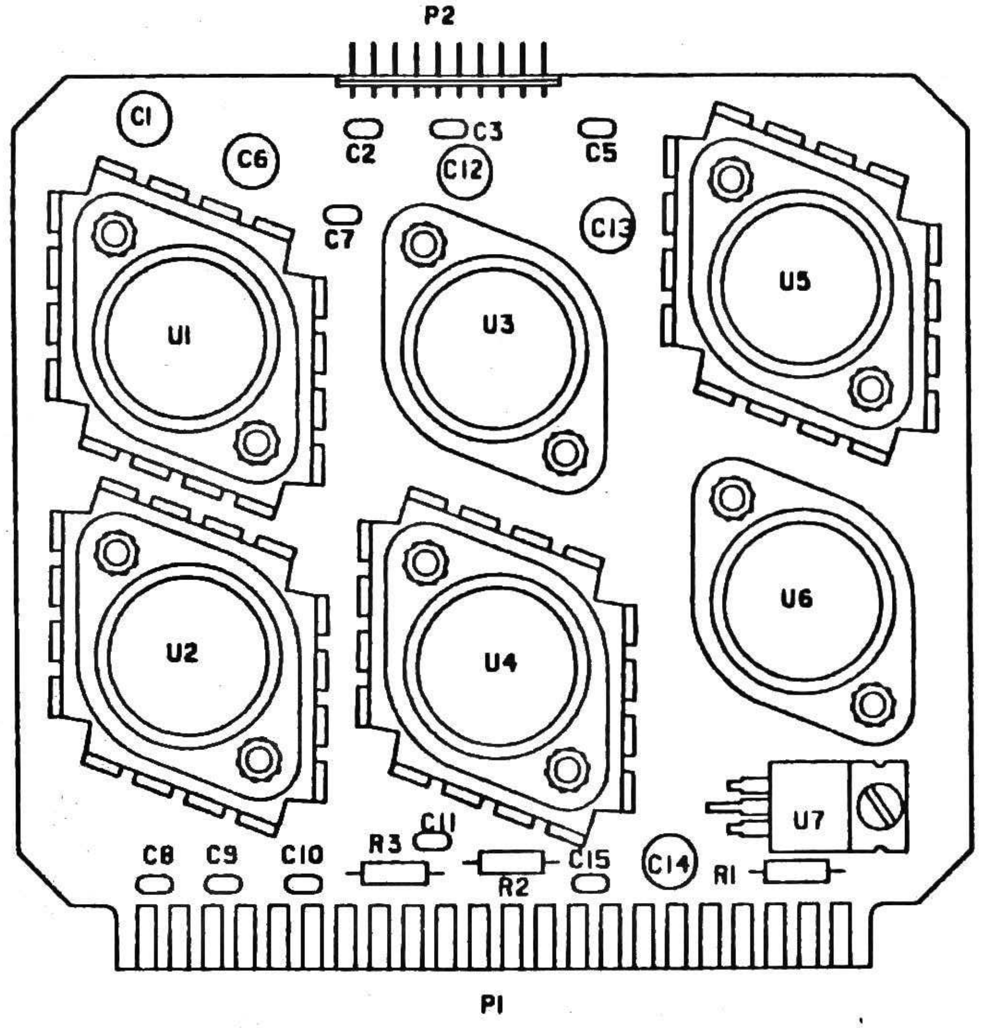
IC200/CE200 Slow Analog Processing Card

IC200/CE200 Fast Analog Processing Card



IC200/CE200 Temperature and Shutter Control Card

REVISIONS					
ZONE	LTR	ECO#	DESCRIPTION	DATE	APPROVED
		-	INITIAL RELEASE	[illegible]	COPELAND



ASSEMBLY

IC200/CE200 Voltage Regulator Card

	0100064
	0100066
0100070	0100067
NEXT ASSY	USED ON
APPLICATION	

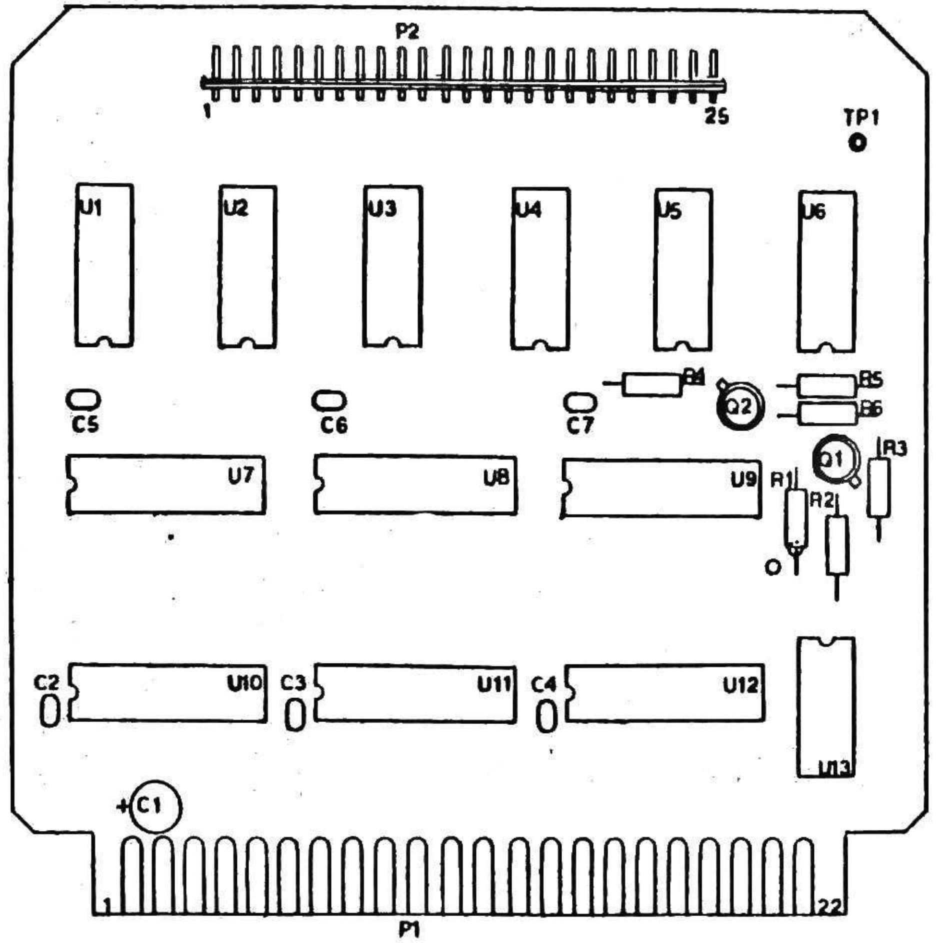
DWN CARTER DATE
CHK DATE
DSGN DATE
ENGR DATE
STDS DATE
MFG DATE
RELBL DATE
CONFG DATE
QUAL DATE

PHOTOMETRICS LTD.
TUCSON, ARIZONA

NOMENCLATURE
VOLTAGE REGULATOR

SIZE	CODE IDENT NO.	SCALE	SHEET	DRAWING NUMBER
C		2 : 1	2 of 4	0100050

REVISIONS					
ZONE	LTR	ECO	DESCRIPTION	DATE	APPROVED



IC200/CE200 Line Driver/Receiver Card

NEXT ASSY	USED ON
0100032	0100032
0100003	0100003

APPLICATION

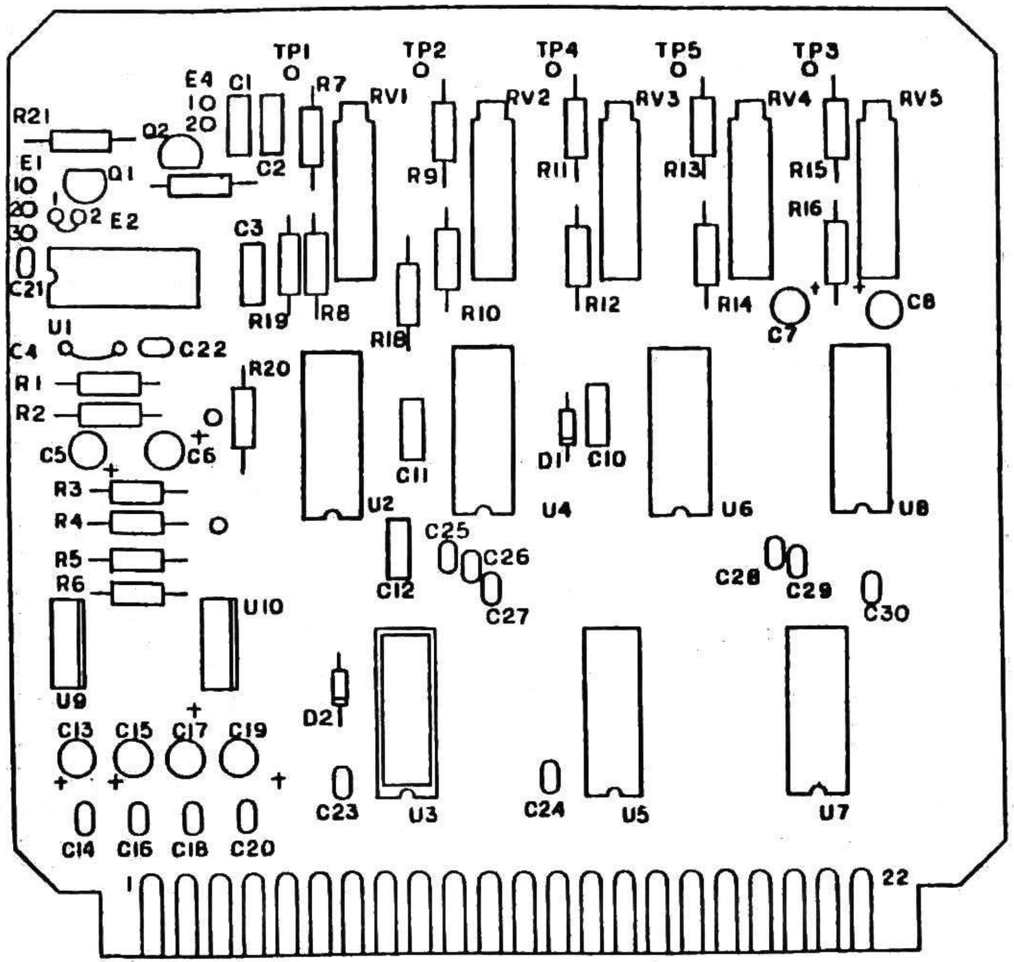
DWN LENNY DATE 4-15-83
CHK DATE
DRGN DATE
ENGR DATE
STDS DATE
MFG DATE
RELBL DATE
CONFG DATE
QUAL DATE

PHOTOMETRICS LTD.
TUCSON, ARIZONA

NOMENCLATURE RECEIVER PCBA
REV C

SIZE	CODE IDENT NO	SCALE	SHEET	DRAWING NUMBER
C		2 : 1	1 of 1	01C0015

REVISIONS					
ZONE	LTR	ECO	DESCRIPTION	DATE	APPROVED



NOTE:

DRAWING FOR COMPONENT LOCATION ONLY.
YOUR CARD MAY NOT HAVE ALL COMPONENTS SHOWN.
ALSO JUMPERS MAY BE USED INSTEAD OF COMPONENTS
ON SOME VERSIONS.

IC200/CE200 Parallel Clock Driver Card

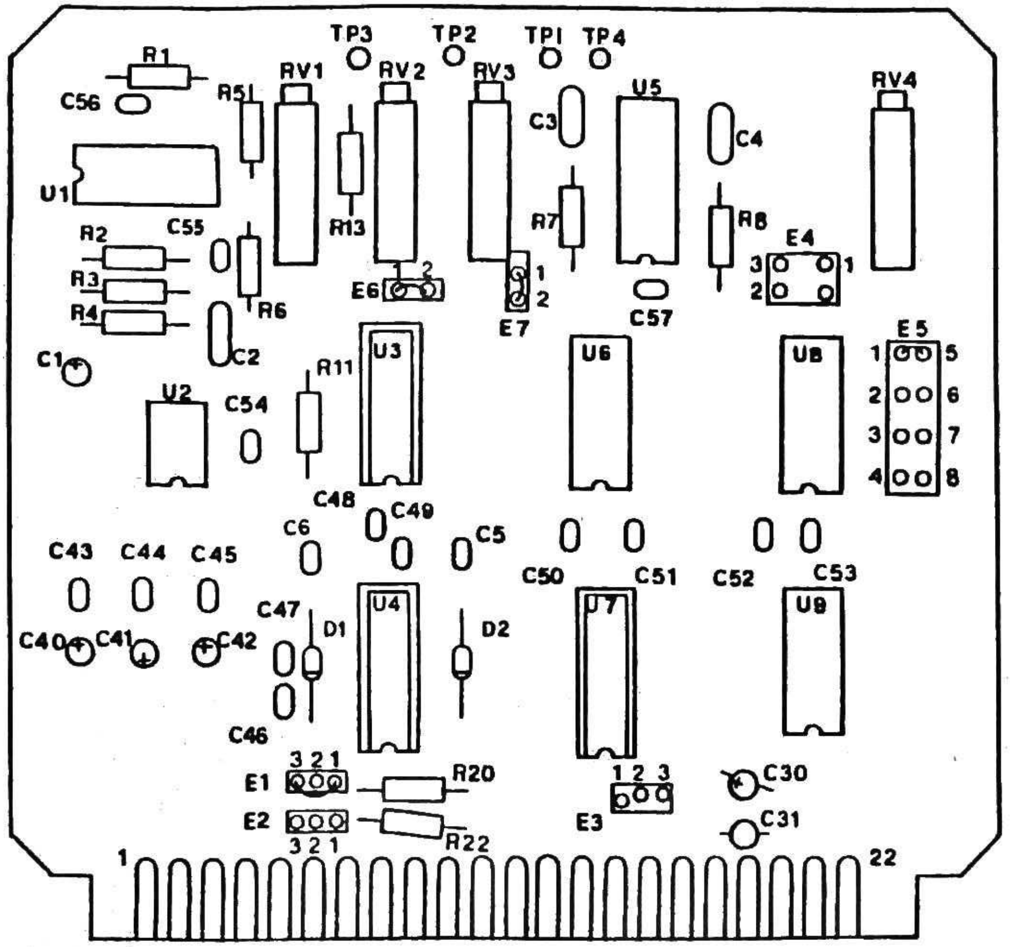
NEXT ASSY	USED ON
APPLICATION	

DWN E. GINN DATE 3-26-87
CHK DATE
DSGN DATE
ENGR DATE
STDS DATE
MFG DATE
RELBL DATE
COMPS DATE
QUAL DATE

PHOTOMETRICS LTD.
TUCSON, ARIZONA

NOMENCLATURE
PARALLEL CLOCK DRIVER

SIZE	CODE IDENT NO	SCALE	SHEET	DRAWING NUMBER
D			1 OF 1	



NOTE:

DRAWING FOR COMPONENT LOCATION ONLY.
YOUR CARD MAY NOT HAVE ALL COMPONENTS SHOWN.
ALSO JUMPERS MAY BE USED INSTEAD OF COMPONENTS
ON SOME VERSIONS.

IC200/CE200 Serial Clock Driver Card

DWN E. GINN DATE 3-26-87
CHK DATE
DSGN DATE
ENGR DATE
STDS DATE
MFG DATE
RELBL DATE
COMPS DATE
QUAL DATE

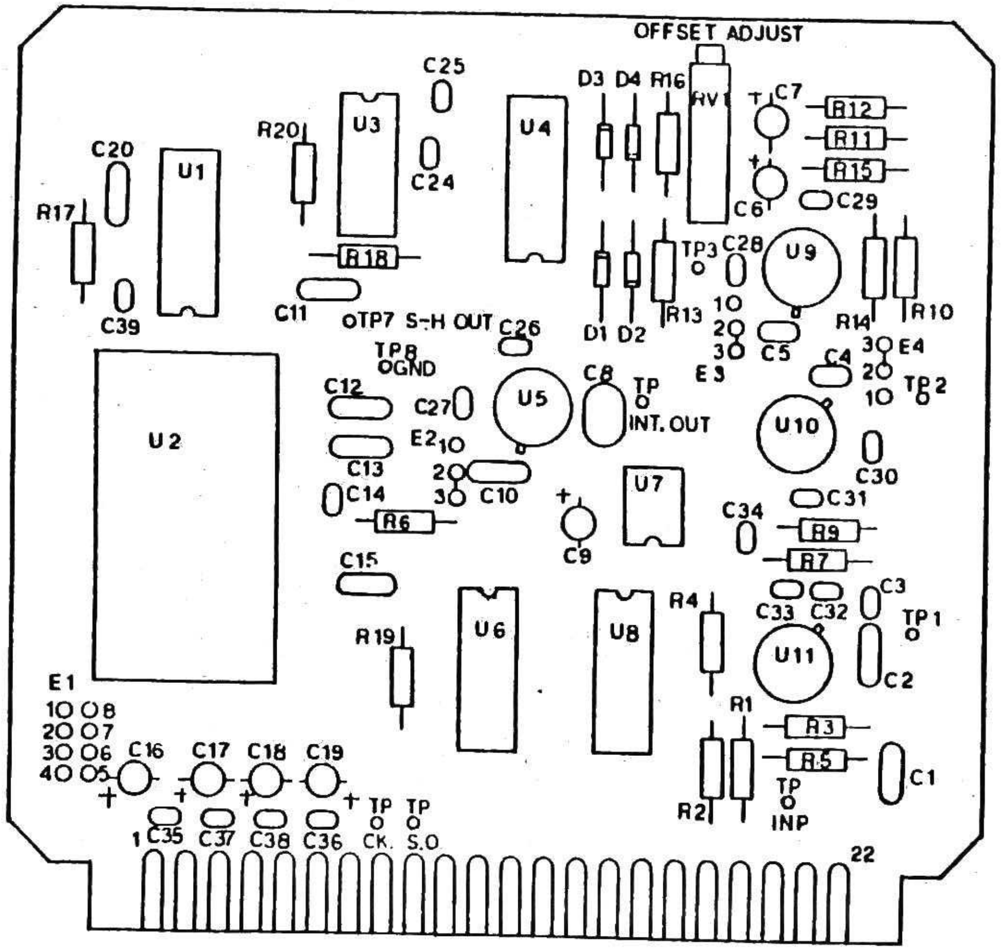
NEXT ASSY | USED ON
APPLICATION

PHOTOMETRICS LTD.
TUCSON, ARIZONA

NOMENCLATURE
SERIAL CLOCK DRIVER

SIZE D
CODE IDENT NO
SCALE :
SHEET 1 of 1
DRAWING NUMBER

REVISIONS					
ZONE	LTR	ECO	DESCRIPTION	DATE	APPROVED



IC200/CE200 Slow Analog Processing Card

0100064	0100064	DWN E. Gust	DATE
		CHK	DATE
		DSGN	DATE
		ENGR	DATE
		STDS	DATE
		MFG	DATE
		RELBL	DATE
NEXT ASSY	USED ON	CONFG	DATE
APPLICATION		QUAL	DATE

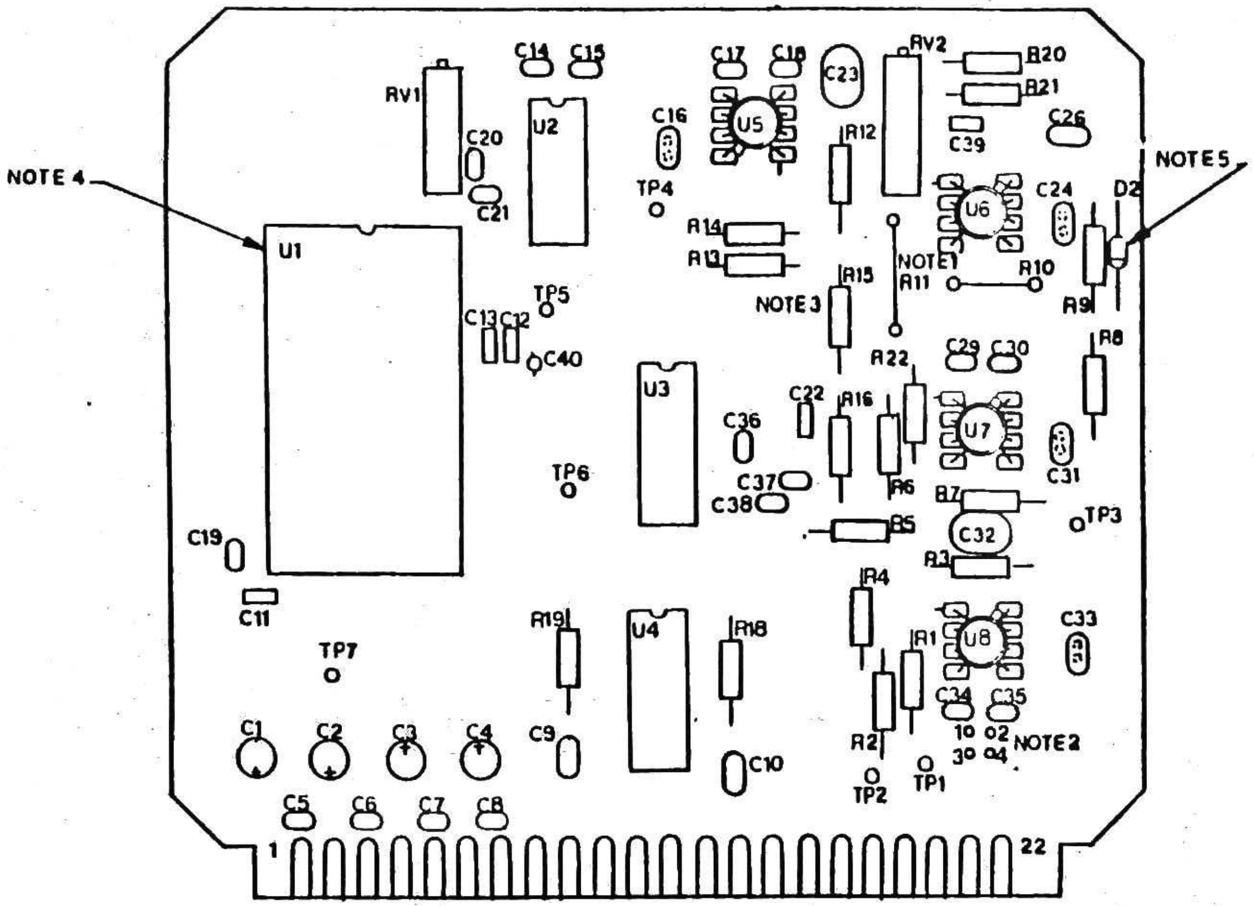
PHOTOMETRICS LTD.
TUCSON, ARIZONA

NOMENCLATURE
CI SLOW ANALOG PCBA

SIZE	CODE IDENT NO	SCALE	SHEET	DRAWING NUMBER
C		2 : 1	2 of 3	0100019

REVISIONS

ZONE	LTR	ECO	DESCRIPTION	DATE	APPROVED



IC200/CE200 Fast Analog Processing Card

NEXT ASSY	USED ON
0100032	0100032
0100003	0100003

APPLICATION

DWN LENNY DATE 8-2-85
CHK ____ DATE ____
DSGN ____ DATE ____
ENGR ____ DATE ____
STDS ____ DATE ____
MFG ____ DATE ____
RELBL ____ DATE ____
CONFIG ? ____ DATE ____
QUAL ____ DATE ____

PHOTOMETRICS LTD.
TUCSON, ARIZONA

NOMENCLATURE FAST ANALOG PCBA
REV E

SIZE	CODE IDENT NO	SCALE	SHEET	DRAWING NUMBER
C		2:1	4 of 4	010CC20

INDEX

prompt, 15, 16

25 load, 13, 14

Analog processing cards
  fast, layout, 67
  slow, layout, 66

Boot kernels, 13-14

bw, 13

Camera head, 23, *24*
  shorting plug, 1

CE200 camera electronics unit, 23, *24*, 31-36
  back panel lights, 34
  CCD temperature control, 23, 35-36
  cabling, 35
  card cage, 31, 33-34
  mounting holes, 34
  power and logic subregulation, 35
  specifications, 31, *32*
  power supply, 34

CH210 cryogenic camera head, 37-41, *38*
  CCD temperature control, 39
  cryogen hold time, 40
  evacuating, 40-41
  filling, 2-6
  molecular sieve, 37
  mounting surface, 37
  neck extension tube, 3, *4*
  precautions, 1, 2
  specifications, *38*, 39-40
  support rod, 1, 3, 37

CH220 camera head, 42-44, *43*
  CCD cooler, 42, 44
  CCD enclosure, 42
  electronics, 42
  liquid cooling, 9
  molecular sieve, 42
  shorting plug, 42
  specifications, *43*, 44

CH220 camera head, 45-47, *46*
  CCD cooler, 45, 47
  CCD enclosure, 45
  electronics, 45
  molecular sieve, 45
  shorting plug, 45
  specifications, *46*, 47

Checkout, 14-16

Disk drives, 23, 26

Customizations, 18

External trigger, 19

Fast analog processing card
  layout, 67

Floppy disk drive, 23, 26

FORTH boot kernel, 14

IC200 integrated camera head and electronics unit, 48, *49, 50*
  back panel lights, 54
  CCD temperature control, 51
  cabling, 54
  card cage, 51, *52*, 53-54
  mounting holes, 54
  power & logic subregulation, 54
  specifications, 48, *49*
  power supply, 54

init 2, 13

init s, 15

mtformat, 26

Line driver/receiver card
  layout, 63

Noise
  KTC noise, 56-58
  noise sources, 55-56

Parallel clock driver card
  layout, 64

Photometrics 3000 computer, 19, *21*, 27-30
  camera controller, 19, 28
  card cage, 27-28, *29*
  circuit boards, 27, 28
  connections, 19
  disk drives, 23, 26
  image memory, 19, 30
  microprocessor, 19, 28
  options, 27
  power supplies, 19
  video display memory, 19, 28

Photometrics 3000 system, *20*
  checkout, 14-16
  hardware, 19-54
  hookup, 6-11
  option 1 (definition), 6, 19
  option 2 (definition), 6, 19
  precautions, 1
  system functions, *22*
  system startup, 11-14
  system shutdown, 16, 17
  voltage, 1

Serial clock driver card
  layout, 65

Slow analog processing card
  layout, 66

Tape drive, 1/4-inch
  integration as UNIX™ driver, 26
  tape formatting (**mtformat**), 26

Temperature and shutter control card
  layout, 61

Terminals supported, 14, 26

Troubleshooting procedures, 59

UNIX™ boot kernel, 13-14
  # prompt, 15, 16
  shutdown, 15

Voltage regulator card
  layout, 62

Winchester disk drive, 23, 26